Weatherwise

Volume 11, Number 5 October 1958

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE"—BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

DAVID M. LUDLUM, *Editor* HENRY W. BULKLEY, *Associate Editor*

National Institute of Atmospheric Research

PLANS to form a National Institute of Atmospheric Research were formally announced recently at the annual awards dinner of the New York Board of Trade. Twelve major universities which specialize in meteorology have agreed to form a nonprofit corporation to plan and eventually to operate the proposed institute. Preliminary estimates indicate that about $60 million would be required to create and run the institute for a five-year period.

The proposals would implement Recommendation 2 of the *Report of the Committee on Meteorology* to the National Academy of Sciences which was issued 25 January 1958. A University Committee on Atmospheric Research (UCAR) has already been established, and planning for the nonprofit corporation is well along. The latter will report to the National Science Foundation which in turn will take the proposals to Congress in 1959 for approval and for the appropriation of funds. A site would then be selected, and the institute could commence operation in 1960, though probably in temporary quarters.

The twelve universities which have officially indicated their intention of joining the corporation are: The University of Arizona, California, Chicago, Cornell, Johns Hopkins, Massachusetts Institute of Technology, Michigan, New York University, Pennsylvania State, St. Louis, the Texas A & M College, and Wisconsin.

Vol. 11, No. 5 October 1958

CONTENTS

The Weather and Climate of Alaska
— J. Murray Mitchell, Jr. 151

Weather and Flying in Alaska
— Maj. C. P. Wood and Capt. J. J. Gleason 161

A Cold Wave Strikes Interior Alaska
— George C. Williams 164

Inside Antarctica No. 2—Amundsen-Scott Station
— Edwin Flowers 166

Naval Weather Service in Alaska
— Com. Paul T. Jorgensen 172

Weatherwatch 174

Front Cover: Davidson Glacier in southeastern Alaska shows the terminal moraine in the form of an alluvial plain at sea level with the 10,000-ft. plus peaks of the Alaskan Range in the background. Official U. S. Navy photo.

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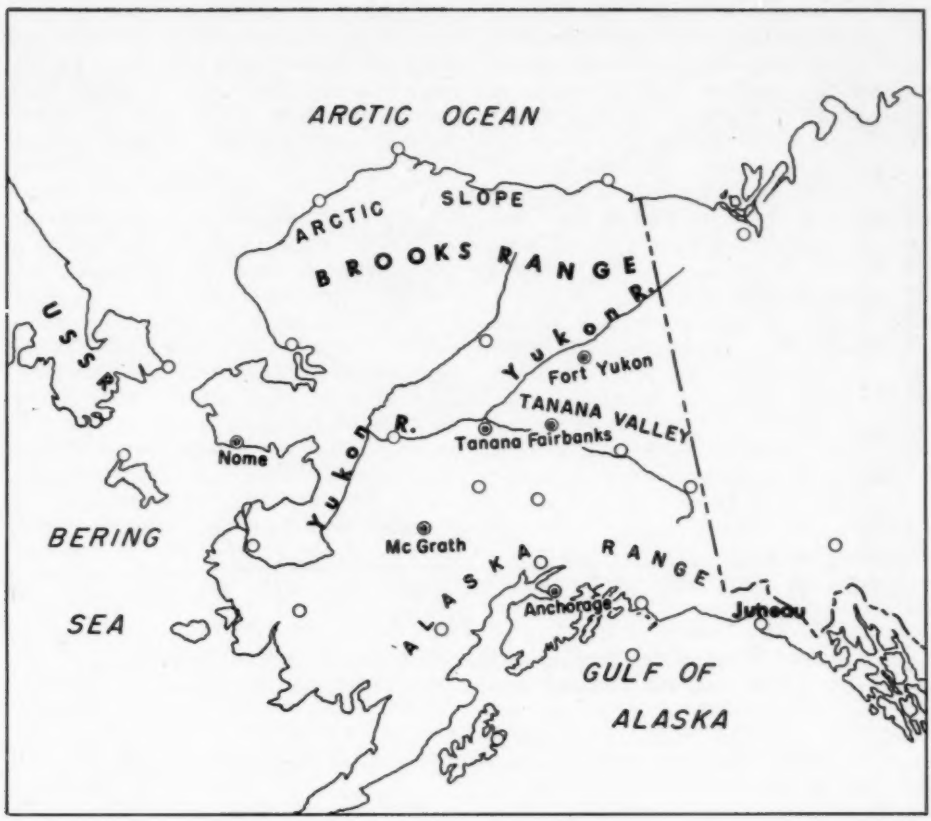
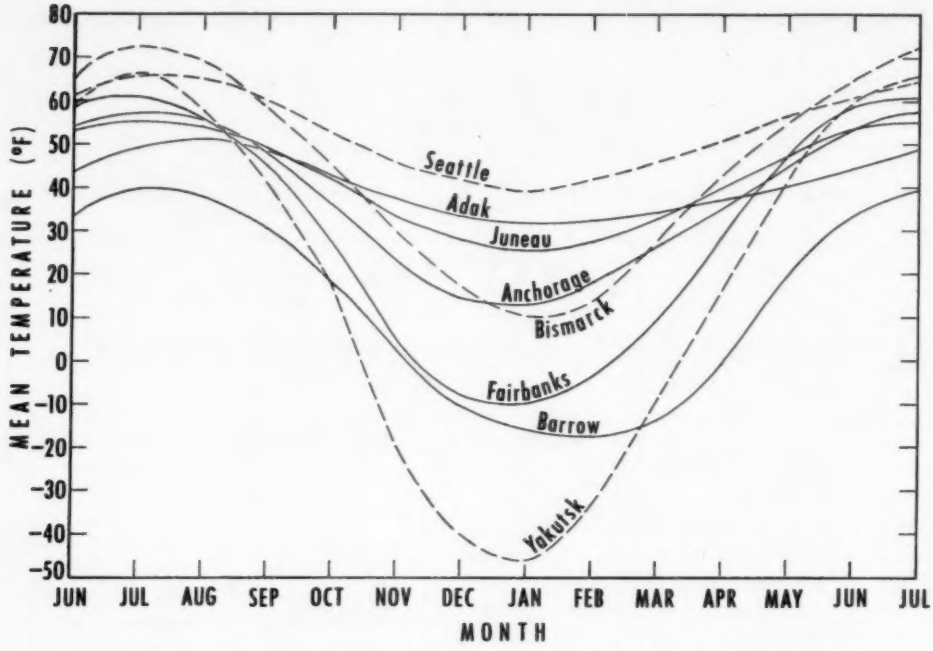


The Weather and Climate of Alaska

J. MURRAY MITCHELL, JR., *Office of Climatology, U. S. Weather Bureau*

SUPPOSE you should meet someone just home from a summer vacation trip, and wonder where he had gone. He tells you only that he has been: sunbathing and swimming in 80-degree warmth; picknicking in a vast meadow of beautiful flowers; eating succulent local vegetables; visiting a friend who runs a thriving dairy farm; ducking a thundershower on a hike along luxuriantly verdant mountainsides; and regretting that he had not brought along more warm-weather clothing. Should our traveller then add a teaser to the effect that the temperature has officially reached 100° there, how many guesses would you need to take before thinking of Alaska?

Ever since our newest member of the Union was purchased from Russia in 1867 as "Seward's ice box," very few Americans have ever come to realize how thoroughly the good Lord defrosts it every summer. Many vacationers who have known Alaska, however, will tell you how wet it is—not how cold, and the chances are they never got very far north of the capital city of Juneau in the "Panhandle," where moist Pacific winds almost relentlessly drive against spectacular glacier-flanked and



Annual March of Temperatures at Selected Places in Northern Hemisphere.
(Solid curves refer to Alaskan stations, dashed curves to stations elsewhere)

COMPARATIVE DATA FOR SELECTED STATIONS IN NORTHERN HEMISPHERE

Station[1]	Latitude (°N)	Longest day (hrs.)	Shortest day (hrs.)	Distance to Arctic tree line (mi.)[2]	Relative rank as to: Coldness[3] Coldest month	Coldness[3] Warmest month	Coldness[3] Year	Dryness[4] Year
Thule, Greenland	77	24[5]	0[6]	1,200	3	2	3	1
Barrow	71	24[7]	0[8]	250	2	1	1	2
Fairbanks	65	21	3	−250	4	7	4	4
Nome	64	21	3	200	5	3	5	7
Yakutsk, Siberia	62	20	4	−350	1	13	2	3
Anchorage	61	19	5	−100	8	6	6	5
Helsinki, Finland	60	19	5	−500	10	8	8	10
Stockholm, Sweden	59	18	6	−600	11	10	13	8
Juneau	58	18	6	−500	12	5	10	13
Moscow, U.S.S.R.	56	17	7	−750	7	9	7	9
Adak	52	17	7	—	13	4	11	14
Seattle, Wn.	48	16	8	−1,300	14	12	14	11
Bismarck, N. D.	47	16	8	−800	6	14	12	6
Montreal, Canada	45	16	8	−600	9	11	9	12

[1] Alaskan stations italicized; order is that of decreasing latitude.
[2] Negative distances indicate that stations are within tree belt.
[3] Based on mean monthly and annual temperatures.
[4] Inverse order of annual total precipitation.
[5] Midnight sun lasts for 16 weeks.
[6] Winter night lasts for 11–12 weeks.
[7] Midnight sun lasts for 15 weeks.
[8] Winter night lasts for 10 weeks.

spruce-forested mountains to produce just about the rainiest weather in North America. If, on the other hand, our traveller remembers (and wishes he could forget) Alaska as a purgatory of utter cold, wet, sunless, wind-swept, treeless desolation, ask him if some military service did not by any chance take him to the Aleutian Islands.

If the above remarks seem contradictory as a description of Alaskan climate, try to imagine the great opportunity for climatic contrasts to co-exist in a region one-fifth the area of the elder forty-eight States, partitioned by several major mountain ranges, stretching over some 58 degrees of longitude and up to 20,000 feet of altitude, and bordered on opposite sides by the ice-congested Arctic Ocean and the warm waters of the Pacific. Texans are not the only ones who are impressed by the sheer size of our forty-ninth star. From Annette at the southeast end of the Panhandle westward to Attu, the tip of the volcanic Aleutian Chain, is about as far for an adventurous crow to fly as from Washington, D. C., to Los Angeles or Seattle. From Barrow on the Arctic coast southward to Anchorage, the territory's largest city located near the Gulf of Alaska coast, is as far over jagged mineral-rich mountains and broad alluvial plains as it is from Seattle to San Francisco, or from Philadelphia to Chicago.

Bearing all this in mind, one can begin to see how hard it is to wrap the climate of Alaska in a neat little package for discussion. In the following paragraphs we shall at least mention the principal determining factors, define (somewhat arbitrarily) three climatic zones, and present some comparative statistics for each, salted with a few remarks on curious weather phenomena in Alaska which are unfamiliar to many of us.

Of the factors which set the climatic stage in Alaska, none is more important than its high geographical latitude, which ranges from 51°N in the Aleutians and 55°N at the southern tip of the Panhandle to 71°N at Barrow. Although no other United States soil can be found so far north, this same latitude belt includes a sizeable part of Europe's prosperous population, from London and Brussels to the northern tip of the Scandinavian Peninsula. Since at those latitudes the sun never climbs very high above the horizon, mean temperatures are relatively low. They are much lower in winter, when the long hours of polar darkness quickly disperse what little heat the low mid-day sun affords. With the approach of summer, however, the long nights yield to equally long days when the circling sun keeps temperatures in a mild range day and night. Seasonal temperature differences are therefore exaggerated, while diurnal differences are rather less in both summer and winter than those to which we are accustomed in lower latitudes.

Equally important in shaping Alaska's climate is the geographical situation. While Alaska's northern perimeter borders on the Arctic Ocean, choked with ice nearly the whole year round, her southern perimeter, together with her Aleutian Chain, is exposed to the vast moderating influence of the Pacific, perennially warmed by the Japan Current.

Between these contrasting ocean masses rise Alaska's great mountain ranges, oriented largely east-west, to form a series of air mass barriers effective against all but the stronger storm winds. The most formidable of these barriers is the Brooks Range to the north paralleling the Arctic coast, whose desolate mass reaches altitudes of 6,000 to 8,000 feet; and the mighty Alaska Range to the south, where the generally 8,000- to 10,000-foot heights culminate in the eternal snow of 20,300-foot Mt. McKinley. The Alaska Range links arms with both the actively volcanic Aleutian Range to the southwest, and with the heavily glaciated St. Elias Range to the southeast (which, in turn, blends into the North American Rockies further south). The mountains form a cradle for the Gulf of Alaska in which the great Pacific cyclones, spawned near the Aleutians, violently spin themselves to death, and where the greatest cyclone frequencies in the entire Northern Hemisphere are to be found. Although these Gulf storms spread heavy precipitation over the countless islands and mountain flanks of the Panhandle, in places exceeding 150 inches per year, surprisingly little of their weather penetrates into the Alaskan interior only a few hundred miles to the north. Oftentimes during the winter a weather map suggests gale-strength easterly winds and heavy precipitation at Anchorage, whereas actually the sheltering coastal mountains, some 7,000 feet tall, have wrung out the moisture and broken

CLIMATE OF SELECTED ALASKAN STATIONS

	Barrow	Nome	Fairbanks	McGrath	Bethel	Anchorage	King Salmon	Cold Bay	Adak[3]	Yakutat	Juneau	Annette
Temperature (° F.)												
Extreme maximum	78	81	93	88	86	86	88	78	75	86	84	90
Average daily maximum, warmest month	46	55	70	68	62	65	63	56	55	59	63	64
Average daily minimum, warmest month	33	44	51	49	47	49	47	48	47	47	47	52
Average daily maximum, coldest month	−11	13	−1	1	15	20	22	33	35	33	31	39
Average daily minimum, coldest month	−24	−2	−19	−18	−1	6	6	24	28	20	21	30
Extreme minimum	−56	−42	−66	−64	−52	−38	−40	−9	11	−22	−21	−4
Frequency[1] max. temp. 70° or above	*	2	47	28	8	13	12	*	—	5	22	15
Frequency[1] max. temp. 32° or below	255	169	154	158	136	111	103	54	—	48	52	22
Frequency[1] min. temp. 32° or below	323	238	231	230	221	202	205	163	—	174	148	86
Frequency[1] min. temp. 0° or below	168	89	121	113	78	35	56	2	—	12	12	*
Precipitation (inches)												
Average annual total precipitation	4	19	12	19	18	14	22	33	47	134	56	97
Average annual snowfall	26	61	60	89	62	61	45	42	71	211	92	53
Maximum observed monthly snowfall	21	24	66	38	57	48	15	22	—	92	54	36
Frequency[1] of measurable precipitation	67	133	111	144	160	102	151	201	—	223	222	221
Wind												
Prevailing direction	NE	E	N	NW	NNE	N	N	SSE	SW	E	ESE	SE
Average annual speed (m.p.h.)	12	11	5	4	10	6	11	18	15	9	8	12
Fastest mile (m.p.h.)	70	75	60	—	—	66	—	—	100	—	68	—
Clouds and Fog												
Mean cloudiness of clearest month (%)	5.1	5.3	6.2	6.2	6.2	6.7	5.8	8.2	—	7.3	7.8	7.4
and month	Mar.	Feb.	Mar.	Apr.	Feb.	Jan.&Mar.	Jan.	Jan.&Feb.	—	Jan.	Jan., May, Jun.	Jan.
Mean cloudiness of cloudiest month (%)	9.2	8.7	8.1	8.6	9.0	7.8	8.6	9.6	—	8.6	8.6	8.6
and month	Sep.	Aug.	Oct.	Oct.	Aug.	Aug.–Oct.	Aug.	Jul.	—	May&Sep.	Oct.	Oct.
Frequency[1] of dense fog[2]	62	24	20	9	20	25	37	41	—	32	21	20
Length of record	37	11	27	15	15	34	15	14	6	11	14	10

[1] Frequency in average number of days per year. Symbol (*) means less than average of one occurrence in two years.
[2] Fog in which visual range is ¼ mile or less.
[3] Data for Adak are U. S. Air Force; all other data are U. S. Weather Bureau as in *Local Climatological Data* publications.

up the wind to create calm, partly cloudy weather there instead.

Meanwhile the broad valleys of interior Alaska—open only to the west from which weather systems seldom enter except during the summer and early fall—are free to radiate away their heat to clear skies, and so to produce their own polar (or Arctic) continental air masses. Like those of the MacKenzie Basin in western Canada, these chilly air masses sometimes drop southeastward as far as the United States under favorable circulation conditions. In winter both sides of the Brooks Range are similarly creative in this way, inasmuch as the Arctic Ocean in the north is then so completely iced over that it becomes a continental rather than maritime air mass source region.

Apart from its localized effect on the western coast of Alaska and on the Aleutian Islands, the Bering Sea does not play a prominent role in determining the climate of Alaska except during the summer and early fall when it becomes the seat of the primary cyclonic center of the Pacific. In other seasons this storm center lies further south and east. Its position in summer permits weather-laden frontal systems to sweep northeastward into the interior, unobstructed by the mountains which at other times allow only their upper-air parts to pass fleetingly over the interior, perhaps dusting it with light snow flurries.

Although the Weather Bureau is finding it useful to identify as many as eight distinct climatic zones in Alaska, three broad zones readily suggest themselves which closely correspond to some of the earliest known efforts to partition Alaska along climatological and ecological lines. These three zones may be identified as *Southeastern and Southern Alaska* (exposed to the Pacific), *Interior Alaska* (the great Yukon Valley together with the state's promising agricultural belt which straddles the Alaska Range), and *Western and Northern Alaska* (under the influence of the Arctic Ocean and Bering Sea) which is taken to include the Aleutian Islands. A thumb-nail sketch of the climate and special weather phenomena of each zone follows.

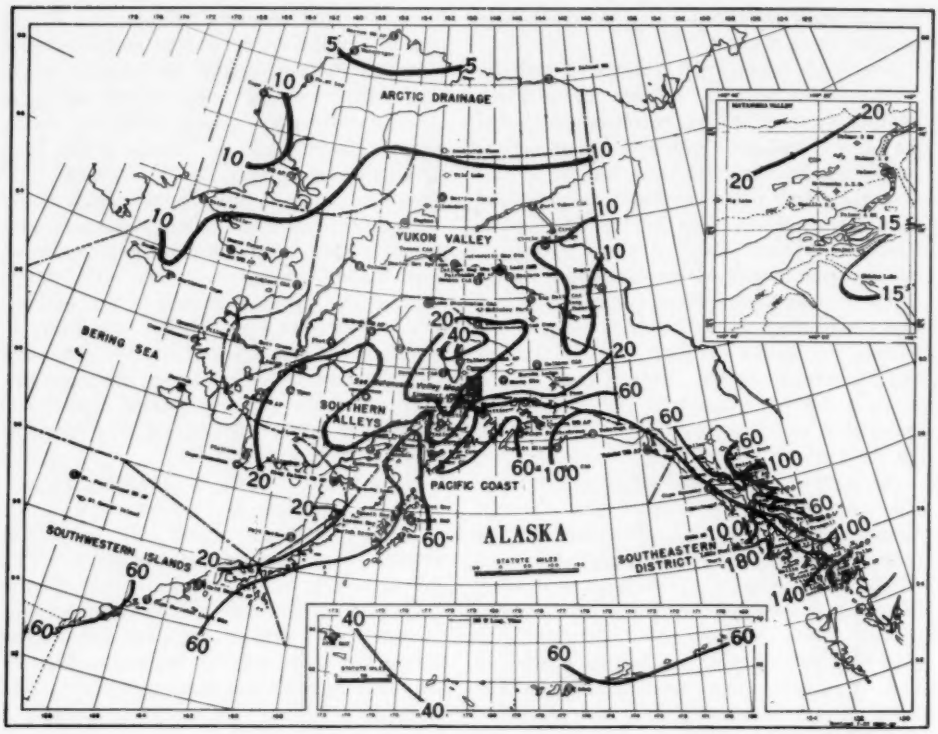
Southeastern and Southern Alaska

Temperatures in this part of Alaska have little annual variation; winters are mild and summers cool. January averages are in the high 20's and low 30's except in the extreme southern Panhandle and on islands in the Gulf where freezing temperatures are quite rare. Occasionally strong northerly winds, however, sweep cold air briefly down from the higher elevations on the Alaskan and Canadian mainland through the coastal mountain passes, sometimes bringing sub-zero temperatures with gusty winds. Summer mean temperatures are mostly in the 50's. Daily highs of 70° are not unusual in the warmest months; extreme highs of 90° have been reported at several stations in this zone, but they are very rare. In winter, ice sometimes collects in the more protected inlets and fjords, but winds and strong tidal currents soon break it up.

Being largely orographic, precipitation generally accumulates to between 60 and 100 inches a year except appreciably less on the leeward side of the coastal mountains. This falls as steady, light to moderate rain or snow during 220 to 230 days in the year; between 35 and 40 per cent of the total accumulates during the three months September–November when the winds are most squarely onshore from the southwest. Cloudiness averages a little more than 80 per cent, with the typical year composed of about 280 cloudy and 40 clear days.

Snowfall is heavy and wet. Because average winter temperatures are near the freezing point, the fraction of precipitation which falls as snow increases markedly with altitude. Also, because of widely varying circulation from winter to winter, in which respect warm seasons are likely to be wet and cold seasons dry, a particular location can experience widely different snow conditions in successive winters. In general, seasonal snowfall amounts range between 30 and 100 inches in this section of Alaska. The greatest measured seasonal snowfall in Alaska was 948 inches, which fell in the winter 1952–53 at Thompson Pass on the crest of the coastal range near Valdez.

The snow season extends from November to early April. Snow remains on the ground for an average of about 40 days a year in the southern Panhandle, and as many as 100 days or more along the north Gulf coast. In about half the years, snow accumulates to a maximum depth on the ground of at least 11 inches



Average annual precipitation, based on data in period 1931–52. Prepared by C. E. Watson, USWB climatologist, Anchorage, Alaska.

at Ketchikan, 20 inches at Juneau, 31 inches at Cordova, and 10 inches at Kodiak.

Thunderstorms are infrequent and mild and can occur at any time of year. Waterspouts in the region of the Panhandle are not unknown. Heavy fogs drift against coastal stations on an average of 20–25 days a year, and come most often in the summer months.

Interior Valleys

Temperatures have a large annual variation, especially in the broad Yukon, Tanana, Koyukuk and Kuskokwim river valleys north of the Alaska Range where July may average 70 to 80 degrees warmer than January. Winters are cold and summers warm. January averages vary from $-15°$ and $-20°$ F in the Fairbanks area to $+10°$ and $+15°$ on the Anchorage side of the Alaska Range. Fairbanks and Fort Yukon each have well over 100 winter days in an average year when temperatures fall below the zero mark, while Anchorage has 35 such days. Winter temperatures north of the Alaska Range typically vary more widely from one day to another than they do from day to night; this region vies with the mountain valleys of the Canadian Yukon and British Columbia as the site of the greatest day-to-day temperature variability in North America. Temperatures at Fairbanks occasionally reach a thawing 40° or 50° above zero in mid-winter, and at other times sink to the -40's and -50's for several days at a stretch. The lowest temperature ever recorded in Alaska was $-76°$ at Tanana. Other stations on the Yukon have also witnessed temperatures in the minus 70's. This compares with the continental North American record low of $-81°$ at Snag, located only 20 miles from the Alaskan border in Canada.

Summer mean temperatures are very pleasant; they average from 55° to 60° throughout the Alaskan interior. Regardless of widespread permafrost underground north of the Alaska Range, which raises hob with road-building and construction, the warmth and almost uninterrupted daylight during the summer encourages growth of dense spruce and birch forests up to a tree-line of 1,500–2,000 feet, and, notwithstanding a growing season of scarcely 100 days, makes possible excellent multi-million dollar yields of potatoes, oats, barley, wheat, turnips, cabbages, and luxuriant greens. Temperatures reach 70° or more on about 50 days a year in the lower Tanana Valley and in the flatlands around Fort Yukon. Elsewhere north of the Alaska Range, this figure is about 40 days a year, and further to the west, as well as to the south around Anchorage, it is only 20 to 30 days a year. Extreme maxima in the high 80's and low 90's are shared by most interior locations. The highest temperature ever officially recorded in Alaska was 100° at Fort Yukon, just inside the Arctic Circle.

Nearly all rivers and lakes in the Alaskan interior are frozen over during the six months from November through April. This fact, along with deeply frozen ground and relatively shallow snowcover, helps to make winter the best time of the year for overland travel, as every Eskimo knows. Some of our remote military outposts are supplied in winter by "snow trains" of enormous rubber-tired cargo tractors which in other seasons have to yield to expensive and inefficient haulage by air. Not only is ice breakup time in the spring the entertaining object of annual guessing games such as the widely participated $100,000 "Nenana Ice Pool," but the resulting ice jams and floods give river-valley settlers some anxious moments.

Generally speaking, annual precipitation amounts diminish rapidly as one moves north of the Gulf coastal ranges and eastward from the Bering Sea, to a minimum of about 7 inches at Fort Yukon. Annual amounts in the agricultural districts along the Tanana and Matanuska Rivers and in the Kenai Peninsula average generally between 15 and 20 inches. Most of these amounts accumulate in summer and early fall as convective showers. Relatively little falls in spring, and the annual distribution is far from ideal for agriculture. Measurable precipitation occurs on about 140 days in the southwestern Interior, on some 100 days in the Matanuska and Tanana Valleys, and on about 70 days toward the northeast at Fort Yukon. Cloudiness averages near 70 per cent, with the typical year composed of about 200 cloudy and 70 clear days.

Annual snowfall amounts average from 80 to 90 inches in the western Interior, but generally about 50 inches at low elevations elsewhere. The snow season extends from early October to the end of April. In about half the years, snow accumulates to a maximum depth (in February or March) of at least 36 inches in the western Interior, about 30 inches in the eastern Interior north of the Alaska Range, and about 18 inches in the Matanuska Valley region.

Thunderstorms, occasionally with light hail, develop during about 10 days a year in the Tanana and upper Yukon River valleys, and lightning fires are a perennial problem for foresters in the Ray Mountains northwest of Fairbanks. Thunderstorm frequencies elsewhere in the Interior trail downward to about one per year in the Anchorage-Matanuska Valley area.

Although most interior stations have sometimes felt 50 mile-per-hour winds, average speeds are only 5 mph., and even less in winter. Locally strong winds produced by peculiar terrain effects are, however, common in the Matanuska Valley and near Big Delta. Under winter conditions of extremely pronounced surface temperature inversions, these winds—made visible from an airplane by the blowing snow they carry—take on the appearance of a stream of water from a hose nozzle which snakes along the ground for surprisingly large distances before breaking up. Winds of this kind, which originate in the Tanana Valley above Big Delta during the winter, have been known to produce strong, gusty winds at Nenana 110 miles to the west, while the anemometer at the Fairbanks airport 40 miles from Nenana hardly moved.

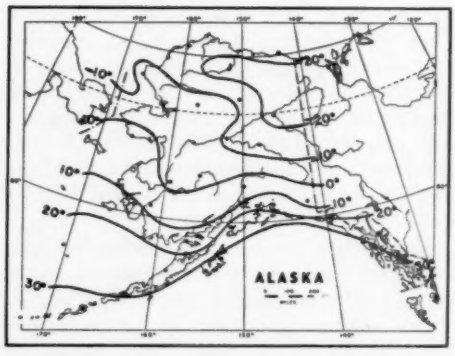
Heavy fogs, reaching frequencies of about 20 days a year in parts of the Interior, are of varied origin and develop primarily in winter. Those around Anchorage, for example, are produced locally as steam fog (Arctic sea smoke) when 20-foot tides break up the ice

on nearby Knik Arm and expose the chill air to the comparatively very warm water. These fogs, made up of supercooled water droplets, adorn the trees with rime and transform them into a glistening white fairyland. On the other hand, the fogs around Fairbanks are ice-particle fogs which locally form in areas of habitation during very cold, calm weather. With temperatures far below zero, combustion of gasoline or other hydrocarbon fuels actually increases the humidity of the air; water vapor is copiously produced by the operation of automobiles, aircraft, heaters, and furnaces. With no wind or convection to dissipate this water vapor, it soon condenses into a cloud of droplets which may persist for hours, or even days. Many an airplane pilot, having taxied down the Fairbanks runway in clear weather, has been surprised to discover that his own engines reduced visibility so much he could not take off!

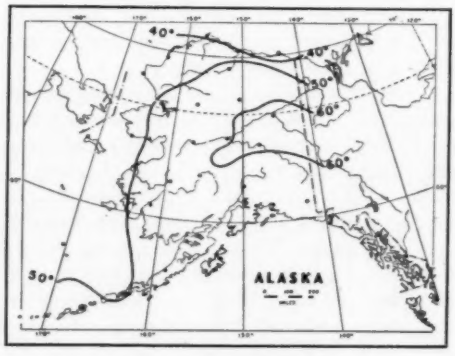
Western and Northern Alaska

Temperatures in the Aleutian Islands have little annual variation, but seasonal differences increase rapidly as one moves north along the Bering Sea to the Arctic coast. January averages in the Islands are near 32°; those further north are about 15° on the north coast of Bristol Bay, 5° on the Yukon Delta, near 0° on the Seward Peninsula, and − 5° in the Kotzebue Sound region. North of the Brooks Range on the so-called Arctic Slope, February takes over as the coldest month with averages near − 15° to − 25° and March nearly wins out over January as the second coldest month. The number of days in an average year with temperatures falling below zero ranges downward from 165 on the Arctic coast to about 90 at Nome, 50 along Bristol Bay, and none at all in the Aleutian Chain. Extreme low temperatures on the Arctic Slope are about − 60°, where nearly incessant winds and the slight flow of heat through the Arctic ice pack thwart the somewhat greater chilling which can occur in the Alaskan Interior. The lowest temperature ever observed in the Aleutians was 5° at Dutch Harbor. Temperatures warm rapidly in April, May, and June in Northern Alaska as daylight returns and the solid ice pack retreats toward the pole. But they never catch up to the warmth of the Interior. July and August are the mildest months, averaging about 40° along the Arctic coast, in the high 40's along Kotzebue Sound, and generally in the low 50's south of the Seward Peninsula and along the Aleutians. High temperatures in the 70's are very rare anywhere in this part of Alaska, and the summer climate is too harsh to support vegetation other than grassy tundra and occasional stands of stunted alder or willow. The ground is permanently frozen north of the Brooks Range, and sporadic permafrost is found as far south as Bristol Bay.

Ice conditions in the Arctic Ocean and Bristol Bay, which mean much to the livelihood of the Eskimos, differ appreciably from



January Mean Temperature (°F.)



July Mean Temperature (°F.)

one year to another. Usually, ice becomes fast against the Barrow shore in early October, and except for occasional leads which open up during the winter remains fast until late July. Even ice-breakers are helpless to cope with it between mid-December and mid-June. As one moves south in the Bering Sea, the ice season shortens considerably. The southernmost boundary of the ice there is near latitude 58°, but navigation is rarely, if ever, suspended as far south as St. Paul Island.

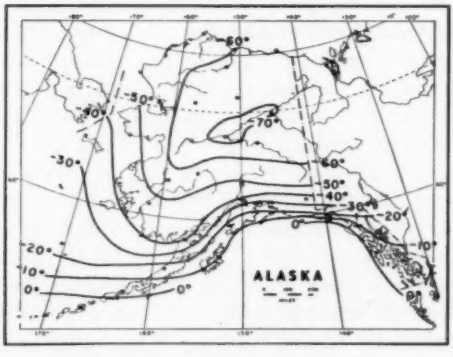
Annual precipitation varies from heavy amounts on the Aleutian Islands (30 to 60 inches, depending on topography) to a desert-like minimum of 5 to 10 inches on the Arctic Slope. In the Aleutians, this is distributed rather uniformly through the year, and falls on an average of about 230 days in the year. Further north, however, the precipitation is largely concentrated in the late summer when the great Aleutian Low has moved northward into the Bering Sea, and much of Alaska is under the influence of a moist southwesterly flow instead of a drier southerly or easterly flow. In an average year, precipitation falls on about 200 days on the western Alaska Peninsula and St. Paul Island, on 125 to 150 days in the Bristol Bay region, and on about 80 to 100 days a year in northern Alaska.

Annual snowfall ranges from more than 60 inches on the Aleutians, falling heavy and wet, to about 30 inches on the Arctic Slope, where it is powdery and dry. In about half the years, snow accumulates to 30 inches or more at Nome (in March), and to 11 inches or more at Barrow (in April). Snow cover is very transient on the Aleutians, but to the north snow remains on the ground for an average of about 160 days at Bethel, 195 days at Nome, 220 days at Kotzebue, and some 250 days at Barrow.

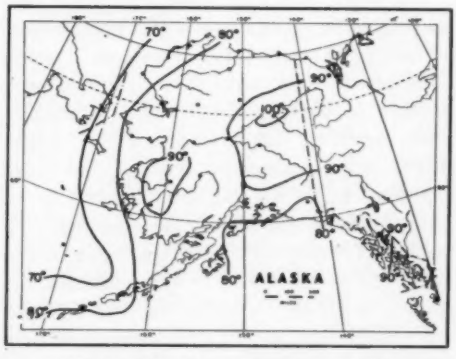
Almost incessant winds along the northern Bering Sea coast and on the Arctic Slope often drive the snow into tall drifts which are nearly as hard as ice itself, and sometimes reduce visibility to a few feet. Extreme wind speeds near or in excess of 100 mph. have been recorded at many stations throughout the Aleutians and in western and northern Alaska. Mean speeds can exceed 20 mph. for months at a time on unprotected islands in the Aleutians and Bristol Bay. Thunderstorms are very rare throughout western and northern Alaska. On the other hand, heavy advective fogs are common in coastal areas during the summer months, and reach frequencies of more than 40 days a year in the Aleutians, about 20 days a year along Bristol Bay, and 60 days a year on the Arctic coast.

Other Notable Weather Phenomena

We have already introduced some of the unusual weather phenomena peculiar to the higher latitudes. Examples are the local mountain winds at Big Delta, steam fog at Anchorage, ice fog at Fairbanks, and extreme effects of blowing snow along the Arctic Slope.



Absolute Minimum Temperature (°F.)



Absolute Maximum Temperature (°F.)

Others which deserve special mention include the great diversity of cloud formations, many beautiful and a few dangerous, formed in large measure by the mountains.

Once in a long while, Alaskans are fortunate enough to see the iridescent beauty of a mother-of-pearl cloud suspended at great sunlit altitudes on a summer night. Even higher, diffuse bluish noctilucent clouds are not uncommon. The greatest of all spectacles of the Arctic heavens—the shimmering, colorful Northern Lights—should be mentioned as a regular attraction in Alaska, although a meteorologist would scarcely claim ionospheric clouds of electrons and protons for his domain.

Moist layers in the atmosphere frequently result in interesting, even grotesque lenticular cloud masses as the wind moves them against the mountains. The stronger, more humid easterly storm winds over the Chugach Mountains occasionally result in dense lenticular cloud layers over Anchorage—these, although appearing menacingly dark, are mostly free of rain and turbulence. Every so often, however, these winds strengthen from the south as the air streams over the Alaska Range and it undulates in an icy "mountain wave" fraught with dangers to aviation.

Visual range in Alaska can be exceptionally great, especially in clear winter weather in the interior. Mountains which normally are out of sight over the horizon occasionally "loom" into full view in the crystal-clear air whose unusual temperature structure actually bends one's line of vision around the earth's own curvature.

But when does high visual range not necessarily imply good *visibility?* The answer: in the "polar white-out." There are times in Alaska when stark white snow-covered ground appears to blend perfectly with an equally white overcast of low stratiform clouds. There are no shadows by which one can judge the shape of the ground, and the effect is the same as being blind or in a dense fog. To walk in a white-out is like stumbling in the dark, and to fly is not to know whether the ground is 10 feet or a thousand feet below. Only the sight of dark or colored objects keeps one from becoming hopelessly lost.

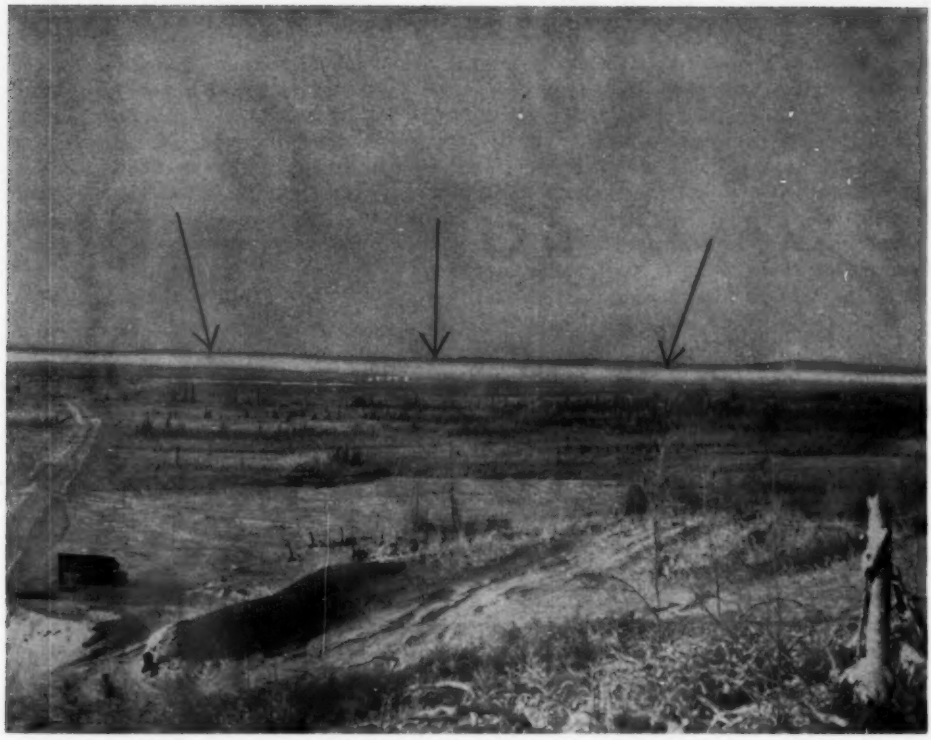
Climatic Changes in Alaska

Nowadays, we hear a lot about the warming of the Arctic and other aspects of the world's changing climate. How does Alaska fit into this picture? Owing to the great natural year-to-year variability of Alaskan climate, any gradual trends which may be present in temperature or rainfall are well obscured in the small handfull of long-period climatological records available. The great glaciers of Alaska's Panhandle, however, have paralleled their Scandinavian counterparts in showing a general recession during recent decades. Although such a measure of the atmosphere's pulse is vulnerable to misinterpretation, it does imply that summers have locally become warmer, or that Pacific storms have changed enough in strength or position to reduce winter precipitation, or both. On the other hand, this glacial recession has apparently slowed in very recent years; only time will tell whether this is symptomatic of important new trends in world climate.

Admission of Alaska to the Union contributes much that is new to something already replete with striking contrasts: the climate of the United States. Even within her own wide borders, as we have seen, Alaska is a land of contrasts scarcely less remarkable!

Acknowledgments

I am greatly indebted to Mr. Robert F. Dale, now the U. S. Weather Bureau's state climatologist in California, and to his successor as climatologist in Alaska, Mr. Clarence E. Watson, for their many helpful suggestions and other assistance in the preparation of this article. Virtually all statistics presented in the text have been taken from the preliminary draft of a forthcoming Weather Bureau publication in the Climates of the States series, written by Mr. Dale. Were it not for the persistent efforts of the many loyal and conscientious weather observers in all corners of Alaska, these valuable statistics and the many important uses to which they are put would be unreachable. It is to these men and women that our thanks ultimately belong.



A patch of ice fog shrouds Eielson Air Force Base, near Fairbanks. It is produced locally in temperatures below about −30°F by the effluent of boilers, heaters, automobiles, and aircraft; frequently closes field. Photo by Stanford Research Institute, California.

Weather and Flying in Alaska

MAJOR C. P. WOOD AND CAPTAIN J. J. GLEASON,
Climatic Center, Hq. Air Weather Service

ADVERSE flying conditions in the Aleutian Islands have led to an exaggerated impression of poor flying weather over all of Alaska. The intense cold encountered at the surface in the interior region of Alaska greatly affects ground maintenance and engine starting, but the cold temperatures at flight altitudes rarely interfere with aircraft operations. In general, the weather permits effective operations in the area which lies at the center of present Air Force activities.

Data compiled from records of the Ptarmigan weather reconnaissance route, Fairbanks to the North Pole and return, show that flying conditions are generally good. For comparative purposes, at 10,000 feet the Ptarmigan route shows a two per cent occurrence of icing as compared to nineteen per cent for the northern routes over the Atlantic. Continuous instrument flight conditions occur only four per cent of the time for the Ptarmigan route, but they occur thirteen per cent of

the time on the North Atlantic. Percentage of the flight time in the clear, on top of clouds or beneath clouds, averages eighty-one per cent on the Ptarmigan compared to only sixty-nine per cent of the time on the North Atlantic. These comparisons indicate clearly the more favorable flight conditions in this portion of the Arctic as compared to the North Atlantic.

Similarly, more favorable terminal conditions are found at the major Air Force installations as compared with many stateside major air terminals. For example, the major U. S. Air Force bases in Alaska, Eielson, Ladd, and Elmendorf, have a simultaneous occurrence of ceilings and visibilities equal to or greater than 1,000 feet and 3 miles more than 90 per cent of the time as compared to 80 per cent for Los Angeles, 77 per cent for Chicago, and 83 per cent for New York.

Regional Flying Weather

Interior

Over this region, unusually good flying weather prevails. In relation to low ceilings and visibilities the summer months provide the best flying weather even though frontal activity is at a maximum. Ceilings less than 100 feet and/or visibilities less than one mile occur 11 per cent of the time during December and January, while in summer the occurrences of these conditions are less than one per cent. Winds are light during all seasons of the year. The worst hazard to flying in this region is found in the shallow layer of extremely cold air next to the surface. It is in this layer that the ice fog phenomenon occurs during winter, causing serious visibility restrictions.

Gulf of Alaska

In general, the winter months provide better flying conditions than the summer months. The occurrence of low ceilings and visibilities varies little from season to season, but there is a slight maximum during the late summer and autumn months. The stations on the outer coast have their maximum fog period in summer, while those farther inland have their greatest amount in the autumn months. In this region, on-top flying can be conducted most of the time. Conditions of fog and low stratus are more prevalent during the warmer months, and restricted visibilities occur more frequently in this season. Kodiak, Alaska, located on the Gulf coast, has a yearly percentage of flying weather as follows: ceilings below 500 feet and/or visibilities below one mile—8 per cent; ceilings above 1,000 feet with visibilities above 3 miles—83 per cent.

Arctic Coastal Region

The best flying conditions in this region occur after the arrival of the Arctic air masses, when most of the sea surface is frozen and the region takes on the characteristics of a continental area. Fog is the main handicap to aircraft operation during the period May through August. During August and September, ceilings and visibilities below 1,000 feet and 3 miles occur 62 per cent of the time.

Bering Sea

Good flying weather is rare and of short duration since this region receives the brunt of all storms moving into the Bering Sea. The main restrictions to flying in this region are low visibilities due to the prevalence of fog.

Aleutians

Overcast skies, low visibilities, extreme turbulence, icing, and strong winds are some of the conditions which make this region one of the poorest for flying in the world. The worst flying season, with respect to low ceilings and visibilities, is summer, with ceilings less than 1,000 feet and/or visibilities less than one mile occurring 50 per cent of the time. The greatest frequency of icing, turbulence, and strong winds occurs in winter.

Weather Hazards Encountered in Alaska

Ice Fog

The ice fog phenomenon is caused by the introduction into the atmosphere at low temperatures of exhaust gases rich in water vapor. Since air at low temperatures is easily saturated with respect to water vapor, in the presence of sufficient nuclei and low temperatures (below about $-30°$ F), the excess

moisture is precipitated out in the form of very small frozen droplets. Their rate of settling is so small that equilibrium conditions between rate of production and rate of settling are established only after serious restrictions to visibility. The primary sources of the moisture are boiler plants, furnaces, automobiles, and aircraft engines. At or below $-40°$ F, the takeoff of four F-86 F's, a B-50, B-47, or a B-36 can temporarily close a field. In fact, the author has seen the preflight engine runup of a B-36 close Eielson AFB so as to prevent the takeoff of the aircraft when it was ready. The area affected by ice fog is dependent upon the source of moisture pollution and the direction of wind drift. This can result in some unusual situations. One end of a runway can have zero visibility and the other end no restrictions in the direction away from the fog bank.

Ice and Snow on Runways and Aircraft

Ice and snow on the runways present handicaps which must also be reckoned with. Alaskan bases have adequate snow removal equipment to keep the runways operational. This does not mean that the runways will always be bare. In cases where a thin layer of ice or snow remains, proper allowance for its effect on steering and braking will allow effective use of the runways.

Snow or ice present on aerodynamic surfaces of aircraft is one of the worst hazards to a successful takeoff. Where insufficient hangar space is available for parking necessary aircraft, the wings and tail surfaces must be cleaned off before takeoff. This is normally accomplished by sweeping the surfaces and then swabbing them with alcohol to remove the adhering ice particles. While successful takeoffs have been made with ice and snow on wings, numerous accidents have resulted—in general, it is a dangerous practice.

Low Temperatures

The extreme low temperatures encountered during the winter season inhibit outdoor maintenance, congeal oil and hydraulic fluids, and, in general, require preheating of the engines prior to starting. The extreme temperatures occur with strong surface inversions. The temperatures above the inversions can be 20 to 30 Fahrenheit degrees warmer than at the surface. The author has encountered conditions in which the propeller feathering system on a C-47 would not operate on the ground because of congealed oil in the propeller dome, yet after the aircraft had taken off and climbed to 2,000 feet the change in air temperature was sufficient to make the system operational.

Supercooled Fog

The occurrence of shallow layers of supercooled ground fog often presents an icing problem. Several cases of severe propeller icing have been reported to have occurred during engine warmup, and severe wing icing has occurred on takeoffs, landings, and even in taxiing.

Arctic Haze

Arctic haze is found during a high percentage of time during which the sky of the Arctic Ocean is otherwise clear at all flight altitudes. Because of the widely varying illumination conditions, little can be said concerning its seasonal variation. It is seldom found over land surfaces, and ground observers can rarely detect its presence. Arctic haze possesses a grey-blue hue in antisolar directions and a reddish-brown hue in the direction of the sun. A reduction of visibilities for aircrews flying in the layer from above the cloud tops to 30,000 feet is the greatest problem presented by this phenomenon. Above 30,000 feet the haze is rarely encountered.

Extreme weather conditions are found in Alaska. Some of these conditions are major impediments to flight operations. Detailed knowledge of the weather and sound planning, however, permit effective air operations in that state.

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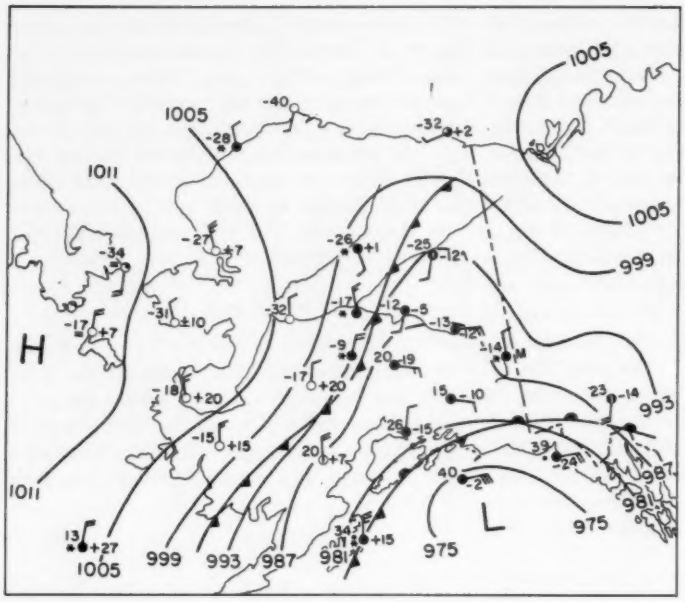

FIG. 1—Weather map for 1430, Alaskan Standard Time, 22 January 1953.

A Cold Wave Strikes Interior Alaska

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THE term "Arctic Front" is used to denote the boundary between the cold, dry, Arctic or polar continental air masses and the milder, more moist air from over the Pacific Ocean. Normally during winter this frontal zone is located in an east-west line which extends across the northern Gulf of Alaska. During the cold season in Alaska, forecasters sometimes note the tendency for the development of a second and more northerly frontal system often located along the Arctic Slope.

The existence of a secondary Arctic Front is a controversial subject among meteorologists dealing with weather of the Arctic and sub-Arctic regions because the frontal zone is frequently so weak and diffuse that it is associated with no surface weather. Occasionally, however, an eastward moving upper trough will activate this zone to the point where it produces definitely frontal weather. At such times the secondary frontal zone may be activated to the point where it will cause a surge of extremely cold Arctic air to overspread interior Alaska bringing $-50°$ to $-60°$ F. temperatures. The secondary Arctic front disappears in spring and usually does not reappear until late fall when airmasses again become extremely cold. In winter forecasting over Alaska, it has been found that dropping a weak front from the charts can result in occasional bad forecasts. This may be due to the fact that at very low temperatures even small scale convergence will quickly produce low cloudiness, fog, and very light snow. Because of this it was the usual practice at the Fairbanks Forecast Center to locate both Arctic fronts on the surface charts by temperature discontinuity even though there was no significant "weather."

SYNOPTIC DESCRIPTION

At 1430 Alaskan Standard Time on 22 February 1953, a deep storm, which had moved into the Gulf of Alaska from the southwest, was continuing northeastward toward the Gulf coast. At the same time a weak low

pressure system was present north of the Alaska Arctic Coast, while high pressure and very cold air covered northeast Siberia. Aloft a cold low with its 500 mb center northeast of the Arctic Coast was becoming more and more dominant with a trough extending in an arc southward and then southwestward.

The Arctic Front extended in a general east-west line through the northern Gulf of Alaska while the secondary Arctic Front, rather diffuse but quite active, was located near a line from north of Fort Yukon southwestward to southeast of McGrath. The latter front was already associated with an area of low clouds, snow, and patches of fog about 50 miles wide. Northwest of the front skies were clear and temperatures ranged from − 30° to − 40° F. even on the Bering Coast. Southeast of the front, skies were mostly cloudy, with cloud bases generally 10,000 feet or higher. Surface temperatures over that area were generally − 15° to − 20° F. at valley stations and higher in the mountains. The secondary Arctic Front was not moving eastward yet since the storm in the Gulf was causing an easterly flow on the north side of the Alaska mountains.

By 2030 AST, the Gulf low had reached the coast and was beginning to fill rather rapidly. At 500 mbs the cold low north of the Arctic Coast had enlarged and deepened dominating the circulation aloft over the area. The secondary Arctic Front still showed little movement, but rising pressure to its west, as well as increased precipitation to its east, gave indication it was beginning to move. The front passed Fairbanks just before midnight on the 22nd accompanied by light snowfall. For ten hours following the frontal passage, cloudiness continued, the wind blew from the west about 10 mph and the temperature dropped slowly from − 10° to − 26° at 1000 AST January 23rd. After this the sky cleared, the wind died down, and during the rest of the day the temperature fell steadily. By midnight the Fairbanks temperature reached − 45° (see comparative RAOB table, figure 3, which shows the changes effected surface and aloft by the frontal passage). During the rest of the night temperatures dropped more slowly and by 0830 AST on the 24th, readings were in the − 50's through much of the Tanana Valley, with the village of Tanana reporting the lowest reading, − 58°.

(*Continued on page 181*)

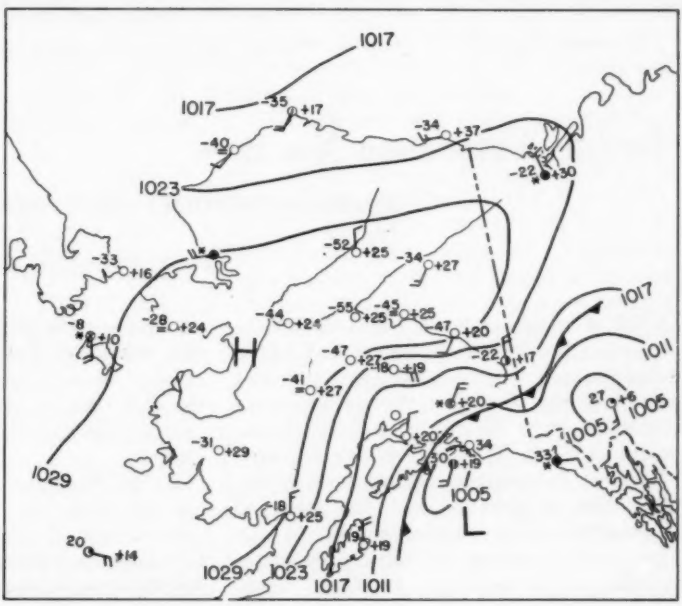


FIG. 2—Weather map for 2030, Alaskan Standard Time, 22 January 1953.

A sweeping curve of the Beardmore Glacier—the "highway" from sea level to the polar plateau and the South Pole.

Inside Antarctica No. 2— Amundsen-Scott Station

EDWIN FLOWERS, *U. S. Weather Bureau*

THE geographical South Pole provides the setting for the current story of US-IGY meteorological activity, a location some two miles high on the Polar Plateau and some 800 miles south of the Little America site described in the last issue of *Weatherwise*. The South Pole project required a vastly different type of operation with the station to be established and supplied entirely by air. First, it was necessary for the United States to build an air facility at McMurdo Sound during the 1955–56 season in order to insure that the South Pole Station would be constructed in time for the IGY. As a result, the Pole Station was not established until over a year after Little America V was occupied.

On 19 November 1956, eight Navy men and eleven sled dogs were landed some eight miles from the South Pole and remained there to commence building the station. Back at the Weather Bureau in Washington, D. C.,

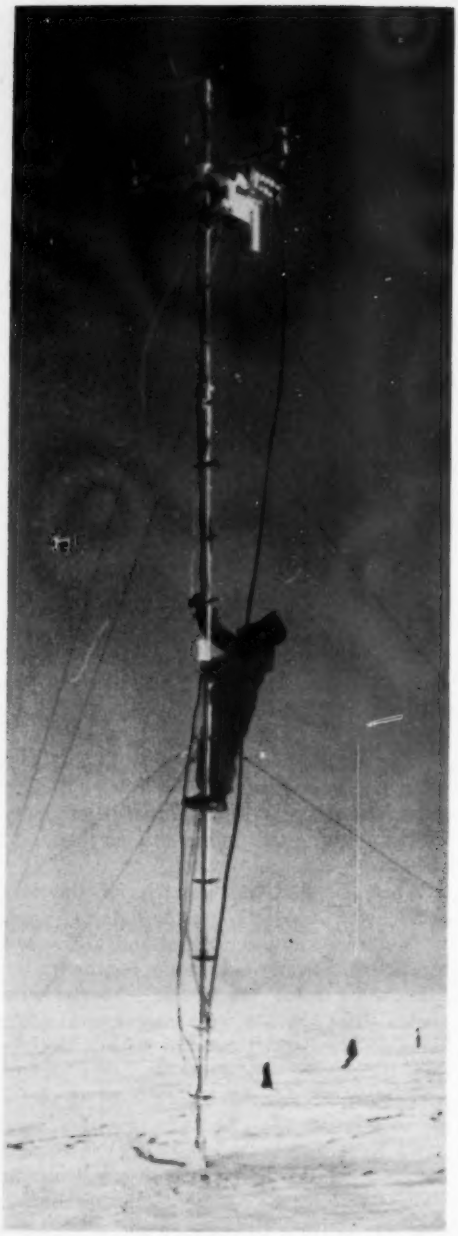
we followed the progress of the station as well as we could from the radio messages arriving from Antarctica, and I began to be anxious to be on the way south.

Finally on the morning of 29 November 1956, in the company of eight other Weather Bureau-IGY personnel, I left Davisville, R. I., aboard a Navy plane bound for New Zealand. Following a six-day layover in Christchurch, N. Z., we boarded the Navy icebreaker *Glacier* for the trip to the Antarctic. Late on the 19th of December, after nine days en route, the ships labored to a temporary berth on the bay ice of McMurdo Sound. From this spot we could look across the ice to Cape Evans on Ross Island where Captain Robert F. Scott had his camp in 1912, the year he and his four companions perished on their homeward trek from the South Pole. In 1912 Captain Scott had walked the 800 miles to the South Pole; now 44 years later, the trip is made by ski-equipped planes—and the time required is reckoned in hours rather than months. During this period in late December, the South Pole Station (later to be named the IGY Amundsen-Scott Station) was fast becoming a reality. Following the initial landing at the South Pole, more Navy men were sent in and the Air Force began paradropping the buildings and supplies. By the time my aircraft landed at the Pole Station on 7 January 1957, the Navy construction personnel had already "gone home" and the camp was gradually being populated by the 18 men (and one dog) who were to man it in the coming year. Dr. Paul Siple, our scientific leader, had arrived earlier.

The flight to the South Pole is one never to be forgotten. For the first two hours the flight is over the flat Ross Ice Shelf with the mountains and glaciers of Victoria Land close on the right. Then directly ahead lies the broad highway leading to the Polar Plateau—the Beardmore Glacier. The plane literally "flies up the glacier" following its curves and increasing its altitude with the glacier. The scene is one of immense beauty with rugged mountains on either side, and directly below the awfully-crevassed surface of the glacier—the very same glacier climbed by Scott and his men. Once the head of the Beardmore is reached the remainder of the flight is over the 10,000-foot-high plateau, featureless except for the tell-tale sastrugi patterns—the wind-etched snow surface that holds clues to the direction and speed of the wind. Two more hours over this sort of terrain brings the South Pole Station in sight.

The first thing you notice upon arrival at the South Pole is the effect of altitude. The calculated station elevation is 9,200 feet although in terms of oxygen pressure it is more nearly like 10,500 feet over the United States. The recollection of a particularly strenuous job always brings to mind the picture of people frantically gasping for breath. The period prior to March 21st, our sunset day, had many such times. From the date of our arrival at the station until sunset we followed a half-day camp work, half-day science routine. During the half-day of camp work we all pitched in to complete the building program and cache all our supplies indoors. Since all our materials arrived by paradrop, the first job was to retrieve them from the drop zone. For this purpose we had a D-2 Caterpillar tractor. However, once the supplies were brought next to camp it was necessary to manhandle them into the storage areas. One of the heavier of these jobs was the caching of several hundred 500-pound drums of diesel fuel. After four hours of this sort of activity we were ready to go back to setting up our particular IGY scientific program. For four of us, Herb Hansen, Floyd Johnson, John Guerrero, and myself, this meant installing all the equipment necessary to carry out a full upper-air, surface, and radiation measuring program.

When the flag was lowered for the long polar night on March 21, the half-day camp work routine came to an end and with a few exceptions the camp was secure for the winter. Life then became less frantic. Movies were shown three times a week and several other evenings were given over to science lectures and discussions. Leisure time never became a problem. Since there were only 18 of us, we all had our turns at washing dishes, fueling stoves, digging snow for water, and various other tasks that always seemed to be waiting to be done. Except for the weather observations each three hours and a few other jobs that required a person to go outdoors, the majority of the work could be performed within the camp. An extensive tunnel system completely surrounded the buildings and allowed access from one building to another



The main meteorological tower at the South Pole. Rain gage near top of mast collected only about one-tenth of the amount received by the surface gage.

without the necessity of going outdoors. The tunnels, of course, were unheated and throughout most of the winter stayed at a steady − 55° F. except for the coldest of days. All of our supplies were cached within the tunnel system so that anything from a scrap of wood to a barrel of fuel could be had with a minimum of effort.

By late April, nearly all our meteorological equipment was up and operating. By this time the twilight period was gone and we began our four months of complete darkness that would be broken only by the appearance of the moon each four weeks. Our eight months of isolation had begun in mid-February with the departure of the last plane.

Another factor told us that winter was fast approaching. Temperatures that had been in the − 10° to − 20° F. range in mid-January had dropped steadily to the − 60° to − 80° F. range by mid-March and then leveled off. Installing instruments outdoors in these temperatures presented many problems. Rubber and plastic covered cables became hard and rigid in a matter of minutes at temperatures below about − 40° F. The method we used for laying the cable was to bring the reel indoors a day ahead of time for thawing. Then after all the connectors were attached the cable was fed outdoors through a hole cut in the building and dragged in a straight line to the instrument exposure site.

Pilot balloon observations were taken beginning the first of February, but were discontinued in early March because of difficulties involved in inflating the balloons in an unheated area.

On March 27th we put the finishing touches on the GMD and the inflation shelter and launched our first rawinsonde balloon. By mid-April we were making the scheduled two releases per day.

The 33-foot wind mast arrived in the airdrops in February, but required a lot of rigging and improvisation before it was ready to be installed. The day we raised the mast on March 5th could not have been a worse day weatherwise if we had waited for one. The wind averaged near 20 knots and the temperature was a chilly − 60° F. With the assistance of several of the Navy personnel we finally erected it and made the necessary cable connections for the equipment to record

remotely. Previous to this date the wind was measured at a height of 10 feet.

In addition to the several wind transmitters, the mast was used to support other pieces of equipment. Resistance thermometers were mounted on the mast, one at a height of 30 feet and another at 15 feet. Other resistance thermometers were placed in the instrument shelter, on the snow surface, and 30 feet below the snow surface. From April through October, the temperature measured at 30 feet below the surface varied by less than a degree from its mean value of − 58.5° F.

The wind mast was also used to support a precipitation gage mounted about 30 feet above the surface. This was an attempt to get a more accurate measurement of falling snow, since the amount of snow collected by a gage on the surface is always biased by an unknown amount of drifting snow. Tabulated below are the collected solid amounts (S.A.) and water equivalents (W.E.) from the two gages. The amounts represent the total collection including snowfall, drifting snow, and frost.

	July		August		September		October	
	S.A.	W.E.	S.A.	W.E.	S.A.	W.E.	S.A.	W.E.
Surface gage	6.9″	1.45″	10.5″	1.50″	1.6″	0.36″	23.5″	6.67″
Gage 30 feet above surface	0.5″	0.09″	1.4″	0.12″	0.3″	0.04″	0.35″	0.04″

Our radiation equipment consisted of a net radiometer for measuring the energy exchange between the snow and the atmosphere and a total hemispheric radiometer for measuring the amount of incoming energy from the atmosphere. With the return of the sun, we exposed two Eppley pyrheliometers, one to measure the incoming short wave energy on a horizontal surface and the other to measure the amount of energy reflected by the snow surface.

In addition to the regular types of observations, air samples were taken for the determination of the CO_2 content of the air using evacuated flasks. Replicas of falling snow crystals were also made when conditions permitted. The most frequent types of crystals observed were bullets and skeleton plates.

With the exception of the 3-cup anemometer, all of our equipment worked without failure and required only a minimum of maintenance. Since our primary wind measuring instrument was an Aerovane, the failure of the 3-cup anemometer did not impair the observation program.

Perhaps one of the most difficult and bothersome problems we encountered was with the launching of the rawinsonde balloons. Provision had been made for releasing the balloons through 8-foot square overhead doors. However, whenever the wind speed was greater than 20 knots, considerable difficulty was encountered in getting the overly-large balloons successfully out of the shelter. The problem was finally solved by erecting 8-foot square windbreaks on the windward sides of the release point. These allowed the balloon to come completely out of the shelter before entering the windstream.

One of the interesting features of the Antarctic stratosphere is the gradual cooling that takes place from February into August and the very rapid warming that occurs in October–November. The cooling trend culminates in minimum stratospheric temperatures of − 90° to − 93° C. measured at altitudes near 18 to 20 km in late July and early August. In an attempt to obtain greater sounding heights in this cold atmosphere, various techniques were attempted for the conditioning of the sounding balloons. The most successful procedure found was soaking the balloon both inside and out in warm diesel fuel. The diesel fuel tended to relax the neoprene allowing the balloon to expand more freely. With this conditioning technique we were able to increase our average sounding height by nearly 3.5 km. However, with the return of the sun in the spring, the diesel conditioning was found less successful than conventional methods.

One of the features we observed early in the year was that the wind rarely fell to calm. We were somewhat surprised, however, to

Floyd Johnson removes frost from radiometer which measures the net exchange of energy between the surface and the atmosphere. The horizontal incidence pyrheliometer bulb for the measurement of short-wave energy is located at left center.

discover that as winter approached the average wind speed increased. The interesting fact that can be seen from the wind summary for June, reproduced in table I, is that of the 720 hourly observations made during the month, no wind speeds less than 6 knots or greater than 30 knots were recorded. June was our windiest month in terms of highest average speed but it was typical of the other winter months as far as speed and direction distributions are concerned.

Even periods of extreme cold were frequently accompanied by winds of moderate speed. Our most severe day in this respect was July 29. On that day the average temperature was $-94°$ F. with a high of $-90°$ and a low of $-99°$, yet the average hourly wind speed for the day was 16.4 knots. Under such conditions, an exposed nose or cheek can be frozen in seconds if the mistake is made of facing into the wind. The trip once every three hours to the weather instruments, which required from 5 to 10 minutes, could be made with a minimum of clothing—a wind-proof

TABLE I

AMUNDSEN–SCOTT, ANTARCTICA

JUNE 1957

	Knots								Nr. hours	Frequency (%)	Average speed
	Calm	1–5	6–10	11–15	16–20	21–25	26–30	>30			
Calm	0	—	—	—	—	—	—	—	0	0	—
N (0°)	—	0	0	2	1	0	0	0	3	0.4	15.0
NNE (22°E)	—	0	1	26	63	53	6	0	149	20.7	19.4
NE (45°E)	—	0	3	63	121	56	2	0	245	34.0	17.9
ENE (77°E)	—	0	12	66	61	8	0	0	147	20.4	15.4
E (90°E)	—	0	13	115	20	0	0	0	148	20.6	13.5
ESE (112°E)	—	0	2	21	5	0	0	0	28	3.9	13.8
SE-NNW	—	0	0	0	0	0	0	0	0	0	—
Total hrs.	0	0	31	293	271	117	8	0	720	Monthly average speed	16.6
Frequency (%)	0	0	4.3	40.7	37.6	16.3	1.1	0			

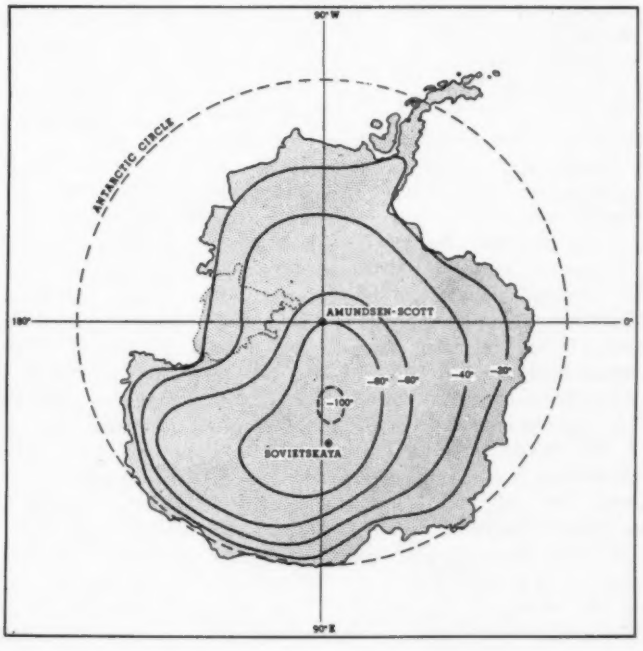
AMUNDSEN–SCOTT ANTARCTICA
90°S

1957	Temperature (°F.)					Pressure (mb)					Wind					Average sky cover (mdt. to mdt.)	Number of Days		
	Average	Extremes				Average	Extremes				Average hourly speed (mph)	Prevailing direction	Peak gust				Clear	Partly cloudy	Cloudy
		Highest	Date	Lowest	Date		Highest	Date	Lowest	Date			Speed (mph)	Direction	Date				
January*	−18.1	− 6.0	11	− 29.8	26	687.8	697.3	11	681.0	27	11.3	0°				6.0	3	14	6
February	−36.8	−18.0	5	− 69.2	28	681.0	696.4	16	671.2	28	11.4	0°				5.0	11	6	11
March	−64.7	−35.0	19	− 82.5	29	681.7	695.6	17	664.6	26	13.4	23°E	32	45°E	23, #	6.0	8	12	11
April	−69.7	−25.6	6	− 89.1	19	681.7	692.9	30	669.8	14	17.3	23°E	39	23°E	5	3.4	17	10	3
May	−68.3	−30.1	15	−100.4	12	684.2	713.2	27	667.5	19	17.2	23°E	54	23°E	25	2.9	19	8	4
June	−69.6	−42.3	12	− 97.0	18	685.7	701.3	15	671.5	12	19.1	45°E	38	23°E	10, @	1.6	27	3	0
July	−77.5	−40.7	3	− 98.8	29	673.2	683.0	16	657.3	30	17.4	23°E	43	23°E	3, ¢	2.0	23	6	2
August	−72.7	−45.4	4	− 99.7	27	682.0	703.0	6	657.3	1	18.0	23°E	38	23°E	1	2.8	20	8	3
September	−80.1	−57.7	30	−102.1	18	677.3	684.7	7	663.1	2	14.7	90°E	42	45°E	29	2.9	19	8	3
October	−62.9	−45.4	18	− 86.1	3	677.3	682.4	7	670.2	20	15.8	23°E	39	23°E	12	4.1	12	16	3
November	−34.4	− 2.2	22	− 54.6	1	688.5	700.3	23	677.3	7	10.9	23°E	32	23°E	23		18	10	2
December	−13.4	− 2.0	15	− 21.5	3	693.5	704.7	18	681.0	30	8.2	23°E	22	23°E	17		14	10	7
Year	−55.7					682.8					14.5								

*9–31.
Also 24, @ Also 25, ¢ Also 4,5.

parka with fur ruff overtop the clothing worn indoors was adequate. Hands were kept warm with large trail mitts worn overtop woolen mittens. However, if a man intended to spend any greater amount of time outdoors or intended to move away from camp more than a few hundred yards, then additional clothing was essential. This would mean wind-proof trousers similar to the parka and adequate

(*Continued on page 179*)



Isotherms of Monthly Average Surface Temperature °F.—June 1958.

Naval Weather Service in Alaska

COMMANDER PAUL T. JORGENSEN, *USN*

THE Naval Weather Service has one of its five fleet weather centrals in Alaska—Fleet Weather Central, Kodiak. Because work concerns sea and coastal weather it is fitting that it should be located on an island.

Kodiak Island, located in the Alaskan Gulf north and east of the northernmost island of the Aleutian Chain, is steeped in the history of exploration and settlement of Alaska. For example, about the time of our American Revolution, Baranoff made Kodiak the center of the Russian exploration and trading activity. The weather had much to do with this early prominence of Kodiak.

The Aleutian Islands have a climatic regime all of their own, and of all the various Alaskan climatic zones it is the one providing the most meteorological drama. This area is so dominated by persistent low pressure that it stands out in global climatology as the "Aleutian Low" area.

SEA CLIMATE

Much has been said about the frequency of storms in the Aleutians. Typical storm tracks for the winter show that a high percentage of disturbances which move across the North Pacific pass into the Aleutian area, but in summer, the number of storms decreases because the average tracks move northward. These cyclones bring high winds, cloudiness, and precipitation—whole days of sunshine are rather rare throughout the islands—temperatures are moderate as befitting a maritime climate.

Responsibility for a year-round warmth in the Aleutian Islands can be traced to the Aleutian (subarctic) Current: a branch flows north of the Aleutian Islands and turns counter-clockwise in the Bering Sea; another branch flows south of the Aleutian Islands. Upon approaching the coast of North America, the ocean river turns north and south as the Alaskan and California currents, respectively. It is the warm Alaskan current flowing counter-clockwise in the Gulf of Alaska that brings milder temperatures to southern Alaska than would normally be expected during the winter at this latitude. The mean water temperature is 40° F. in January and warms to 52° F. in August. This high January mean temperature at a latitude well north of the U. S.-Canadian border is a prime example of the warming effect of the Alaskan current.

Precipitation is normally heavy in the Aleutian area. There is some form of precipitation on 187 days of each year at Kodiak, with 239 days at Adak. The Aleutian area receives 40 to 75 inches of snowfall annually. Fog, which is most common during the summer period, hazards both surface and air transport. Seventy per cent of the observations show cloud ceilings over Kodiak and ninety per cent over Adak. These clouds are predominantly stratiform with bases usually varying between 1,000 and 5,000 feet. Occasionally, they drop as low as 200 feet for periods from a few hours to almost a day.

This is the area of the strong wind known as the Williwaw, occurring most frequently in winter, usually as the result of damming up of cold air on the windward slope of mountains to be later released by a very gusty overflow to the lee side. Because the Williwaws represent cold air drainage from higher terrain, they exist only as long as the supply of dammed-up air lasts, frequently only a few minutes. Such winds, however, are violent, often reaching hurricane speed.

NAVY WEATHER SERVICE IN ALASKA

From Fleet Weather Central, Kodiak, area synopses and forecasts are issued to describe wind, sea, and weather for the waters of the northeastern Pacific Ocean, the Gulf of Alaska, and the ice-free sections of the Arctic Ocean. When appropriate, storm warnings are issued. These are vital to hundreds of ships on the U. S.-Orient great circle route, and also serve the islands and coastal towns of Alaska.

Alaskans depend on air transportation because there are months when most of the overland travel is impossible and overwater routes are only open during the summer months. In this aviation-minded land the Fleet Weather Central, Kodiak, flight weather information is employed for routes from Kodiak to Seattle, Kodiak to Adak, or

Kodiak to such Alaska mainland points as Point Barrow, Fairbanks, Nome, or any of the far-flung cities of this vast land. Navy operational over-ocean patrol flights are frequent within the Alaskan Sea Frontier, and the U. S. Coast Guard at Kodiak also flies SAR (search and rescue) and other missions over these waters. Here low visibility, icing, and turbulence are a constant concern for the forecaster. Thus, Fleet Weather Central, Kodiak, maintains a flow of needed weather information continuously twenty-four hours each day.

Weather service, of course, is most dependent upon communications. The chattering teletypes and sizzling facsimile of the Weather Central receive and transmit over one million word groups each month. Incoming U. S. data are relayed by the Civil Aeronautics Administration through Anchorage then over the Air Force-developed "White Alice" circuitry to Kodiak, where it is received with the assistance of the Naval Communications Station, Kodiak. Similarly, information from all over the northern hemisphere and from ships and planes at sea is garnered to plot and analyze so that forecasts may be prepared.

Some Fleet Weather Central men carry the designation "Aerial Ice Observer." In this capacity they are regularly flown across the vast state of Alaska to make observations of Arctic Ocean and Bering Sea ice. During the summer season, they report the existence of channels through the ice (leads) to the U. S. Navy Hydrographic Office so that agency can forecast safe tracks for the ships which will follow the northern coast line to re-supply the DEW line stations. During the fall ice accretion season and the spring ice diminishing season, the ice boundary is flown weekly as it moves from above the Arctic Circle to the latitude of the Pribilof Islands in the Bering Sea. Imagine making a 250,000 square mile skating pond (about the size of Texas) each winter and you have an idea of the yearly ice formation in the Bering Sea. An interesting part of this weekly exploration flight is the sighting of the Big and Little Diomede Islands which are in the narrow Bering Strait which separates the United States and the U.S.S.R. Aerial Ice Observers claim that this provides more of a thrill than their previous Navy experiences of "crossing the line" (Equator) or "entering the Kingdom of the Golden Dragon" (crossing the international date line from east to west).

Alaskan Phenomena

Some of the phenomena that Fleet Weather Central, Kodiak, and all peoples of this clime encounter, such as glaciers, ice fogs, permafrost, and extreme durations of sunlight, deserve special mention.

Glacier ice represents that part of the earth's water budget which originates from the accumulation of solid precipitation on land. At present the volume of existing glacier ice is only 1 or 2 per cent of the

(*Continued on page 180*)

Approximate average position of edge of ice sheet in Bering Sea for selected months. Data based on *Ice Atlas of the Northern Hemisphere* (1946).

Weatherwatch

Data by Office of Climatology, USWB.

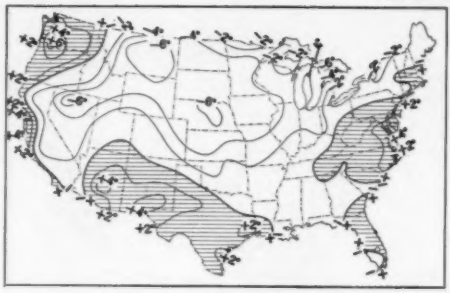
A July Heat Wave in Far West Spreads Eastward

DAVID M. LUDLUM, *Editor*

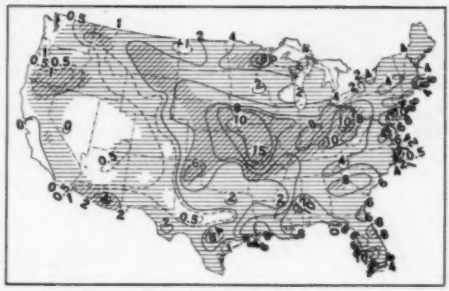
The turbulent atmospheric conditions which so distinguished the weather pattern over a greater part of the United States in June continued to make headlines in the first full summer month. The general circulation features of June—western ridge with hot, dry conditions and eastern trough with cool and humid weather—were again marked on the July mean circulation maps. It was another hot and dry month in the Northwest, the hottest calendar month ever experienced in some places, and in the desert Southwest several new all-time maxima were set in a blistering heat wave in early July. But the upper Mississippi Valley, Great Lakes, and Ohio Valley, under a different circulation pattern, experienced one of the coolest Julys of record and also one of the wettest. Along the Atlantic Coast there was marked contrast between a cool Maine and a very warm Cape Hatteras.

CIRCULATION—A glance at the mean maps for July shows two main pressure features which provide the keys to the circulation of this memorable month. Outstanding in all respects was the eastern lobe of the great Pacific Ocean anticyclone, centered northeast of the Hawaiian Islands, but with a very strong ridge extending northward along the 130°W longitude from the tropics to the North Pole, a blocking position from which it could interdict all cyclonic traffic out of the northeast Pacific Ocean. Not a single storm center crossed the coastline south of Alaska to break the reign of clear skies and subsiding air along the Pacific slopes of Canada and United States. Pressure aloft along the British Columbia coast showed an unusual plus departure from normal. This pressure anomoly was reflected in temperature and precipitation conditions, for instance, at Seattle, Washington, where it was the warmest month of record and also close to the driest with only a trace of rain falling to equal the aridity record.

The contours of the great north-south ridge along 130°W sloped downhill sharply. There was a minor trough directly south over California, and, of more importance, a well-marked trough area eastward extending from the Hudson Bay area into Illinois. The jet stream as it approached North America took a sharp northward swing over Alaska and northwest Canada, to pass around the northern part of the great ridge, and then swept sharply southeastward to plunge into the central trough, bringing an



Departure of Average Temperature from normal in degrees Fahrenheit. USWB chart.



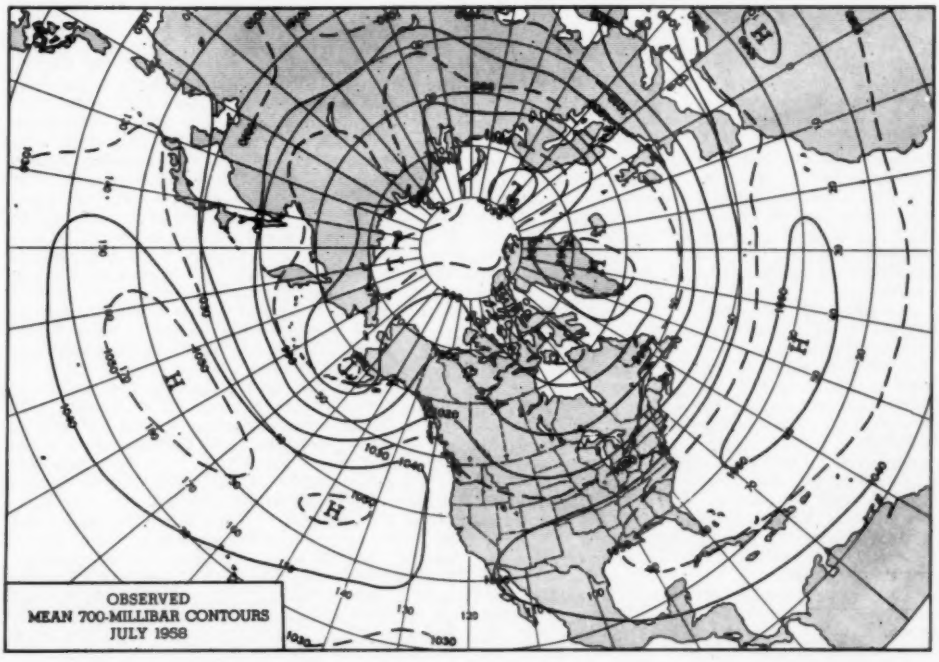
Total Precipitation in inches. USWB chart.

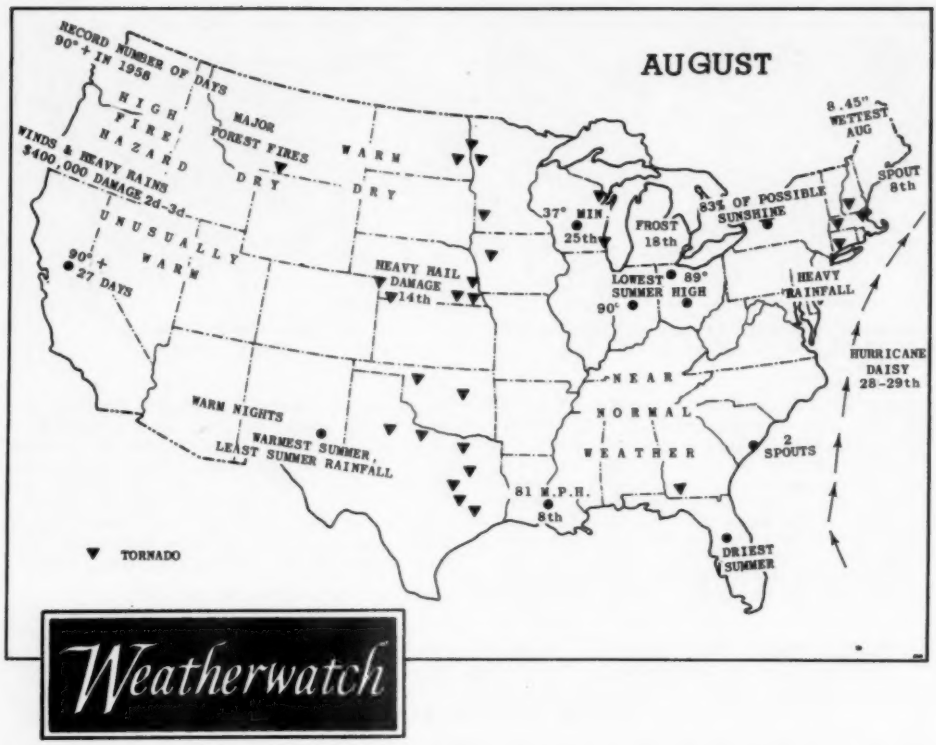
exchange of cool polar air masses direct from the cold Arctic into the Mississippi Valley. No less than seven anticyclones, each carrying a new impulse of cool air, passed over the Lake Michigan area. Chicago's weather summary of *cloudy, cool,* and *humid* held for most of the central parts of the country—i.e., north of the Kansas-Missouri-Ohio River axis. Many stations over the expanse from eastern Nebraska to New Jersey had their wettest July.

Another major anticyclone also operated in conjunction with the general low pressure over eastern Canada and the upper Mississippi Valley. As expected at this season, the great Atlantic anticyclone had gained considerable stature in June and by early July stretched from the West African coast across the Atlantic and Gulf of Mexico all the way to Lower California. Its main axis lay in an east-west direction along 30°N latitude, which in North America passes near Jacksonville, Florida-Del Rio, Texas—to a point well south of San Diego. Like its

(*Continued on page 178*)

The upper-air map below shows the pattern of air flow for July at about 10,000 feet, on which the average weather largely depends. The contours lines represent the mean height of the 700 mb. pressure level. Figures are in tens of feet: 1020 = 10,200 ft., 980 = 9,800 ft., etc. Chart by Extended Forecast Section, USWB.





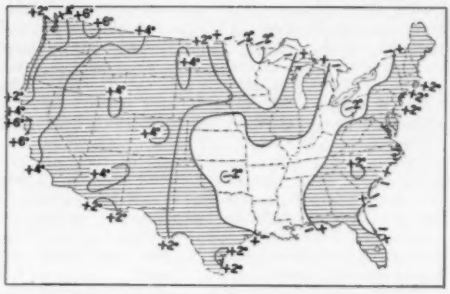
Weatherwatch

The circulation pattern in late July and early August underwent major transformations which brought important changes in the temperature and precipitation regimes of various parts of the country. Whereas in July, two large anticyclones had played the chief roles in directing air currents over North America, the dominance of high pressure decreased rapidly in early August and sea level pressures over the United States were below normal for the month everywhere in the contiguous forty-eight states. Such a change in pressure patterns is very unusual as July and August normally show the greatest continuity of weather types of any two consecutive months.

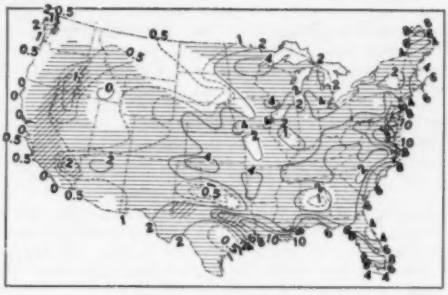
A high index of westerly flow replaced the low index type of July, and this important shift in air movement was signaled by pressure changes along the Pacific Coast early in the month. The eastern Gulf of Alaska, seat of the strong blocking ridge in July, was now occupied by an active cyclonic system with a marked trough line along the 150° W meridian. A southeastern extension of this system appeared in a deepening trough which paralleled the California coast about 250 miles offshore. Across Canada from the Gulf of Alaska to central Quebec low pressure persisted through the month to provide an easy channel for the development and movement of cyclonic centers seeking to travel eastward from the Pacific Ocean.

The August pressure format—low pressure off the California coast and a trough running west-east across Canada—induced a general southwesterly air flow over the western half of the nation. Thus, hot air, confined in July to the fiery furnace of the desert Southwest, spread over the Plateau, the Rockies, and the Great Plains; where temperatures had been well below normal in July, now they were much above. For the first time of the current summer the mercury soared to torrid levels in the grain belts, and farmers welcomed real corn-growing weather after a long spell of cool and wet conditions. The second and third weeks of August witnessed a succession of searing days with above 90 and 100 degree readings widespread. Bismarck, North Dakota, experienced its hottest weather since 1949 with a blistering 109° on the 9th. For August, as a whole, it was a very warm month west of 100° W with large areas averaging four degrees above normal. In most of the Northwest and in parts of the Southwest it marked the conclusion of the warmest summer of record.

The eastern part of the country, too, underwent important circulation changes. The changing pattern is perhaps best illustrated by the behavior of the sea level pressure at Cape Hatteras where a plus departure from normal of 1 mb. in July gave way to a 5 mb. deficit in August. The shift in pressure altitudes aloft was equally marked. A trough occupied all sections east of the Mississippi River with its main axis extending southward from central Quebec, through New York State, and then southwestward following the trend of the coastline to the eastern Gulf of Mexico. The trough broke through the bulwark of the great Atlantic anticyclone, the mainstay of the July mean maps, which was much reduced in strength especially over the Southeastern



Departure of Average Temperature from normal in degrees Fahrenheit. USWB chart.

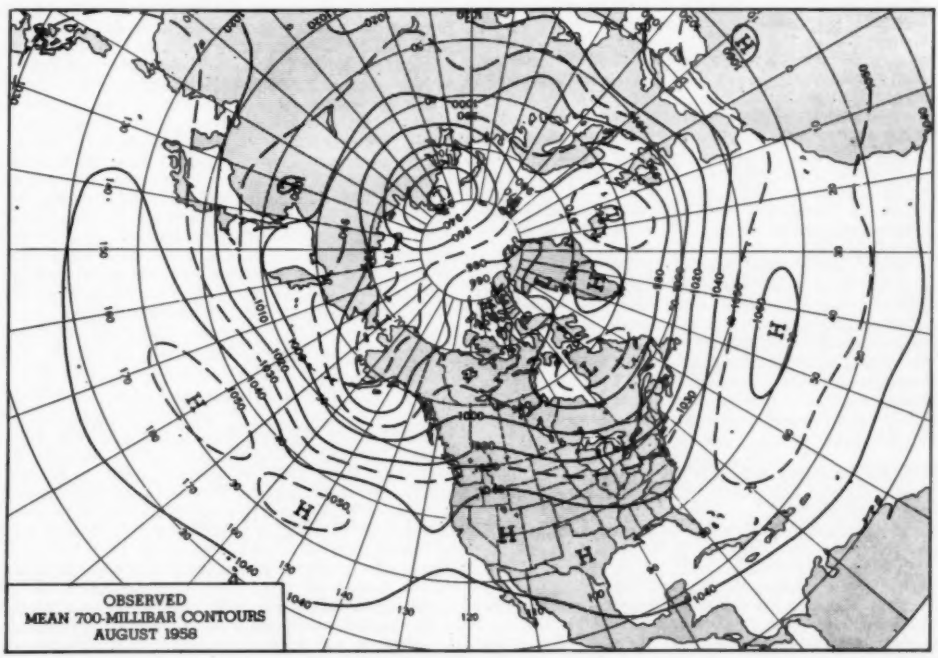


Total Precipitation in inches. USWB chart.

states and the West Indies. Now the way was open for the formation and northward movement of tropical storms; three—Becky, Cleo, and Daisy—appeared in the Atlantic Ocean north and northeast of the West Indies at relatively high latitudes for this type of storm. None, however, formed in the Gulf of Mexico despite seemingly favorable circumstances of low pressure and trough action as evidenced on the surface weather maps.

Air flow over the eastern half of the country changed frequently throughout August as cyclones and anticyclones in succession moved in and out of the eastern trough, borne along by the accelerated westerly current which was especially strong from 12–16 and again 26–30 August. It was during these periods of strong westerly flow that the highest temperatures of the month occurred in the East. In the Southland, cold fronts, which had been unable to penetrate the power of the July ridge conditions there, moved southeastward with regularity in the second half of August to break the monotony of the Southern summer.

A growing dryness became apparent as the month progressed. From the upper reaches of the Missouri River southeastward to Florida, though there were frequent air mass changes, the air was mainly of Pacific origin, was stable, and had a long trajectory over land. Gone was the zone of convergence in the Ohio Valley latitude where so much overturning of the atmosphere had taken place in July. Flood waters there generally receded under the influence of sunny skies and below normal rainfall.



The most interesting map situation developed on the 24th as a deep low over Hudson Bay protruded a deepening trough over the Mississippi Valley at the same time that a tropical storm, Daisy, was making an appearance near the Bahama Islands. A strong northwesterly flow of polar air followed in the wake of the trough to bring the first intimation of approaching winter. Temperatures dipped below freezing on 25 August at the usual cold spots along the northern border—Cranmoor, Wisconsin, boasted a 24° reading that morning.

HURRICANE DAISY—An intense, but small tropical storm was detected about 300 miles east-northeast of Miami, Florida, on Sunday, 24 August 1958. A report from the ship *Alamar* indicating low pressure and strong winds provided the first clue to the developing storm. A Navy reconnaissance flight into the area subsequently confirmed its existence.

The tropical storm developed into a hurricane on 25 August. It drifted northward very slowly for three days until east of Jacksonville, Florida, when its forward speed accelerated to about 20 mph. Daisy reached maximum intensity on the night of 27–28 August when about 400 miles east of the Georgia coast. Strongest winds were estimated at 125 mph. and central pressure was reported down to 935 mb. (27.61″). It was still a very small hurricane in area with hurricane force winds extending westward about 50 miles.

The storm center at 1400 on 28 August was about 75 miles east of Cape Hatteras and moving northward on a course just east of due north at a forward speed of about 22 mph. Cape Hatteras reported its highest wind at NNW 27 mph. Advisories continued to consider Daisy "a severe hurricane," though of rather small size. A hurricane watch was issued by the Boston weather bureau for Rhode Island and southeastern Massachusetts at 1100, and this was changed at 1600 to full hurricane warnings.

During the night of the 28–29th the storm center turned toward the northeast and eventually to the east-northeast. This track brought the center southeast of Nantucket Island at 0950 on the 29th where a radar fix located it about 65 miles distant. With the course now almost parallel to the coastline, the small area of very strong winds did not reach any coastal points. Block Island reported a "fastest mile" of 40 mph. with gusts to 45; Nantucket had 42 mph. from the north with a gust to 55. Precipitation at Nantucket amounted to 3.26″ with the heaviest rain falling from 0500 to 1100 on the morning of the 29th.

As the storm center sped away to the east-northeast, a "Texas tower" radar installation at sea about 120 miles east of Cape Cod, reported gusty winds of 87 mph. and steady winds of 69 mph. as the center passed nearby. Available post-storm reports indicated no appreciable damage or loss from the storm. Nevertheless, Daisy provided a fine workout for our coastal hurricane surveillance equipment and taught us one more lesson about the inner complexities of the hurricane.

WESTERN HEAT WAVE—West of the Continental Divide abnormally warm weather persisted nearly all month, and a number of stations with long-term records reported their highest average temperatures for any August. In fact, August was the fourth consecutive abnormally warm month in the Northwest and along the Pacific Coast, and the summer in these areas either was or was among the warmest ever recorded.

Seattle, Washington, had an August temperature 3.4° above normal, to mark the fourth consecutive month that all-time high monthly averages have been reached. Only 0.04″ precipitation fell there until the 27th. At Portland, Oregon, the all-time August record was exceeded by 0.7°, and the period June–August topped the previous summer record by 1.4°. A period of 57 days without measurable precipitation was broken on the 27th when 0.01″ was measured.

Inland it was hot, too. During the summer Spokane, Washington, had 36 days with 90°-plus, a new record. Walla Walla, Washington, had its second warmest August and the warmest May–August of record. At Yakima, Washington, there were 60 days with 90°-plus, three more than the highest previous mark with September still to come.

Further south, both Red Bluff and Sacramento, California, had their warmest Augusts with persistently high nighttime temperatures, though no daily maxima were set. Downtown Los Angeles experienced its fourth warmest August, while San Diego had its third warmest August.

To illustrate the contrasts that the Golden State can produce, coastal Eureka turned in its August maximum of 67° and its minimum of 50° on the same day—29 August.

GROWING DROUGHT—Unlike June and July, precipitation in August was generally below or much below normal. An area of extremely light rain included most of the Dakotas, Montana, Washington, western Oregon, and coastal sections of California north of San Francisco. Monthly totals were generally less than 25 per cent of normal in South Dakota, and less than 50 per cent in the remainder of the area. The worst effects of this deficient rainfall were felt in the northern Great Plains where moisture for crops had been either short or barely sufficient during the previous part of the growing season.

Reports at the end of the month indicated a need for rain in western Minnesota, most of Wisconsin, northwestern Iowa, most of South Dakota, north and central North Dakota, and the eastern and parts of the western portions of Montana. Some of the following station reports indicate to some extent a measure of the dry spell: Boise, Idaho, reported the driest August since 1941, and Pocatello the second driest on record. In Montana, Glasgow had its 12th dry month in a row and only 47 per cent of precipitation for that period; Devil's Lake received only 0.80″ or 35 per cent of normal; Portland, Oregon, had only 0.03″ in August, and also 57 consecutive days without measurable rain, a near record dry spell broken by 0.01″ on the 27th. Milwaukee, Wisconsin, for the year to date has measured only 10.37″, the driest such period on record there.

July (*Continued from page 175*)

counterpart in the Northwest, the southern anticyclone proved a barrier to cyclonic movement, preventing the penetration of fronts south of the Ohio Valley and inhibiting the formation and northward movement of tropical storms. Nevertheless, a zone of convergence between polar air masses flowing out of the western ridge and tropical air from the Gulf out of the southern anticyclone created an air mass battle ground to supply the central and northern states with continuously moist and humid conditions.

The southern anticyclone at its western extremities lay over the hot desert of northern Mexico where it

pumped dry, intensely hot air into Arizona, New Mexico, and western Texas to set some new all-time highs and to establish at Yuma, Arizona, a new run of consecutive days with unbroken extreme heat.

JULY FLOODS—Extremely heavy rain falling over southwestern Iowa early on July 2nd produced critical flash flooding in the area. The worst floods on record resulted as the heavy rains fell on already saturated soil. Audubon, Hamlin, and Exira were the hardest hit towns. Audubon, about 75 miles west of Des Moines, registered an official rainfall of 12.35 inches during this storm with other stations reporting five to seven inches.

The following week shifted the scene southwestward to eastern Kansas and eastern Nebraska and adjoining parts of Missouri. On July 10th and 11th locally excessive rains with amounts up to seven inches sent rivers over their banks with levels approaching the 1951 highs. The Missouri River from St. Joseph downstream exceeded flood stages. Rains continued to fall in Illinois and Indiana with 8 to 10 inches in north-central Illinois causing flash floods.

The third week of July brought almost daily shower activity throughout the central Great Plains, middle Mississippi Valley, and portions of the Ohio Valley, resulting in general flooding along most streams. Flooding was critical over the Missouri tributaries in northern Missouri where heavy downpours on the 19th produced high levels on streams already over their banks; the Grand River at Brunswick was more than 11 feet over flood stage. The Mississippi River rose above flood stage from a point south of St. Louis to Cairo, and at St. Louis reached the highest stage since 1 May 1952. Further east heavy rains in western Pennsylvania caused serious flood damage on the Shenango and Beaver Rivers.

The final full week of July continued the earlier pattern although there was some relaxation in the intensity of rainfall. Light to moderate flooding continued on the middle Mississippi, lower Missouri, and lower Ohio rivers. Two flash floods claimed nine lives at two points in West Virginia. In one instance a family of seven was drowned when their home was struck by a wall of water in the middle of the night.

At the month's end most streams from Missouri to Ohio were either in light flood stage or bankful. The upper Mississippi River was in light flood stage from Alton, Illinois, to Cape Giradeau, Missouri, a distance of 150 miles. The rivers of eastern Kansas went over their banks again after four to six inches fell on July 31st. The Illinois River had been in light flood since mid-June and was running high as the month ended. In Iowa the Grand, Marais des Cynges, and Osage rivers, above flood stage since early July, were still covering much valuable farm land. Heavy rains in Indiana kept the White and Wabash over their banks as they had been since mid-June.

WETTEST JULY—All-time precipitation marks for July were established at many stations stretching all the way from eastern Nebraska to Massachusetts, and other stations approached new total records and established marks for most cloudiness, least sunshine, and generally humid air conditions and wet soil. At Peoria, where rainfall records have been maintained since 1855, July 1958 was the wettest since 1860, a notoriously wet year, and this year's total of 8.42 inches missed the 98-year record mark by only 0.45 of an inch. Some of the stations in the zone which recorded their wettest July follow with totals and greatest 24-hour falls in parenthesis:

Lincoln, Neb.	11.40″	(4.11″ on 9–10th)
Des Moines, Iowa	10.51″	(5.14″ on 1–2d)
Springfield, Mo.	18.75″	(6.85″ on 6–7th)
Columbia, Mo.	11.45″	(1.90″ on 16–17th)
Evansville, Ind.	9.69″	(2nd wettest)
Peoria, Ill.	8.42″	(2.66″ on 2–3d)
Toledo, Ohio	6.71″	
Akron, Ohio	11.43″	(4.18″ on 30–31st)
Columbus, Ohio	10.07″	(2.47″ on 31st)
Parkersburg, W. Va.	12.05″	
Baltimore, Md.	11.50″	

Along the northern Atlantic Coast, too, there were some exceptional totals. Nantucket had falls of 2.14 and 2.40 inches on the 27th and 29th to raise the month's sum to 7.45 inches, an all-time July high. But further south it was a completely different story—Cape Hatteras, under an anticyclonic circulation pattern, had a very warm and humid month though measuring only 0.45 of an inch (all of which fell on the morning of the 18th), the lowest by far of any previous July total or of any summer month. For the village of Hatteras, which depends almost entirely on cistern-held rain for its water supply, the prolonged dry spell necessitated seeking emergency supplies of water from outside sources.

NORTHWESTERN HEAT WAVE—The heat pattern of May and June continued to hold much of Washington and Oregon in its grip. Both Seattle, Washington, and Eugene, Oregon, had their warmest calendar month ever recorded. At the Puget Sound city only three days were below normal and the greatest daily departure was only −2. There were six days with maxima of 90° or more, topped by a 98° mark on the 28th. Precipitation for the month was virtually nil (only a trace on the 31st), and there were an unusually large number of bright, sunny days.

Portland, Oregon, had nine days with a maxima of 90° or more, raising the June–July total to 15, well ahead of the previous record for the first half of the summer. Inland Yakima registered a 104° top on the 28th, the warmest there since 1942. Along the coast onshore circulation kept readings down—southward along the California coast, fog-bound Eureka had a maximum of only 66° for the entire month.

SOUTHWESTERN HEAT WAVE—The desert states of the Southwest experienced a hot spell of remarkable intensity during the second week of the month when some all-time maxima were set and a record for severe heat persistency made. Yuma, long noted for searing maxima, established a string of five consecutive days with readings 116° or higher with the peak 119° on the 9th. At Tucson a new all-time maximum was reached with 111° on the 11th, and Winslow's 106° has been exceeded only once. Further east, Albuquerque in New Mexico had top readings in excess of 100° on five consecutive days, 10th to 14th. At Roswell, New Mexico, new all-time marks for any day or month were set: 109° on the 13th and 110° on the 14th. El Paso's 106° on the 12th lacked only one degree of the all-time maximum there. The month of July averaged as much as four degrees above normal from central Arizona to western Texas as tropical continental air, conditioned in the deserts at Mexico, held sway.

Antarctica

(*Continued from page 171*)

footwear, generally large thermal boots. Even dressed to the teeth, it was imperative to keep moving in order to stay comfortably cool during the most severe conditions.

Our wind observations also brought out the fact that nearly all of our coldest days occurred when the wind direction was from 90°E longitude. This implied the existence of higher terrain and a colder climate in that direction, the advective effects of which were not entirely compensated by the adiabatic heating of the descending air. Figure 1 is a map of the isotherms of surface temperature (monthly averages) for June 1958, indicating that the cold pole of Antarctica probably exists somewhere between our South Pole Station and the Soviet IGY Station, Sovietskaya.

In October, the Air Force Globemasters returned after an eight months absence and began making airdrops of supplies at the station. Toward the end of October, in − 60° F. weather, the Navy landed their first plane of the spring season and in the succeeding weeks other planes landed and the transfer of personnel began. Kirby Hanson, the new meteorologist-in-charge, and his crew arrived and soon took over the weather observations. The enthusiasm of the new group was sufficient to tell us that we had been there long enough. At 2000 on the 30th of November, four of us departed the station in a Navy R4D-8 for the flight to McMurdo. After a short rest there we boarded an Air Force C-124 Globemaster bound for New Zealand, where ten minutes before midnight on December 1st we stepped into the summery night air at Christchurch. From the barren snow plain of the South Pole to the plush green fields of New Zealand in slightly over twenty-four hours—a remarkable transition not only in terms of time but in climate and scenery as well. After the first day in the civilized world of tea in bed and green grass and seeing once more members of the opposite sex, the South Pole seemed very remote indeed.

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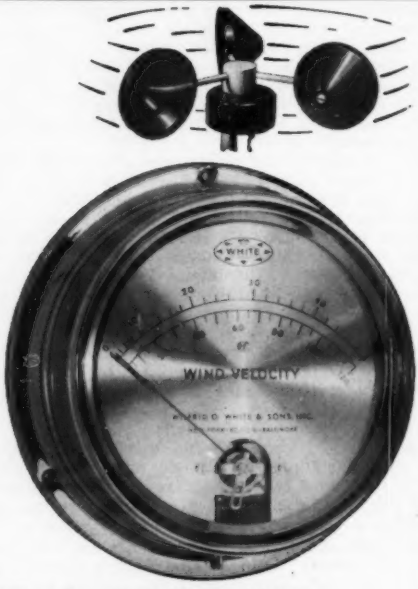

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Naval Weather Service

(Continued from page 173)

volume of the oceans. It is highly critical for if it were to melt it would cause the sea level to rise and inundate widespread coastal areas. Alaska, in particular, has a very fine display of glaciers. They are largest in those areas which combine elevation and copious supplies of moisture (i.e., the mountainous coastal regions of southern and southeastern Alaska). Fleet Weather Central, Kodiak, has a part in the current aerial photographic study of Alaska's glaciers.

Permafrost or perennially frozen ground is encountered in many parts of Alaska. It means that all subsurface material has frozen from the surface level down, occurring in continuous, discontinuous, or sporadic zones depending on climatic effects. In Alaska the greatest known thickness of about 1,000 feet is in the area south of Pt. Barrow. The engineering significance of this phenomena is tremendous. It must be considered in construction, in sewage disposal, and road building. Permafrost can be used as a base for or even as construction material, but steps must be taken to insure its stability; otherwise, it must be destroyed and appropriate steps taken to prevent its reformation.

Ice fog forms when the temperature is low enough to cause direct atmospheric sublimation of moisture in the form of ice crystals rather than as sub-cooled water droplets. This type of fog is particularly prevalent where local combustion products supply an abundance of condensation nuclei; for under the right conditions, by providing an immediate nucleus, an individual can startle the clear atmosphere in his vicinity into ice fog.

This article has tended to present the exceptional, and so it is an excusable practice to promote Alaska as a fabulous land—twice the size of Texas, with the 20,300-foot Mount McKinley, and gold or platinum available for the taking. In the same vein, Alaska has a reputation for a cold, rigorous, Arctic climate, and is popularly thought of in terms of igloos, glaciers, and eaves-high snowfalls. But in many respects this is an erroneous conception, for the greater portion of this vast area possesses a climate as favorable to human habitation as that of the other forty-eight states.

A Cold Wave Strikes

(*Continued from page 165*)

During that day the secondary Arctic Front had surged eastward and the cold air moving 35 mph up the Tanana Valley was well into northwestern Canada by 0830 AST on the 24th, figure 2. Although the cold air had been able to move rapidly eastward along the Valley, it was not immediately able to penetrate the barrier of the Alaska Mountains, and the cold air continued to pile up on the north and west slopes of the Range. As a result there was a 20 to 30 degree temperature differential between air masses across the mountains and this, as well as the strong pressure gradient, resulted in severe turbulence through the passes.

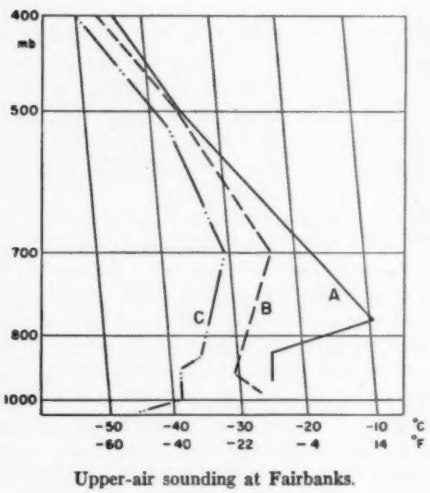
Pressure in the cold air had risen rapidly and by this time a 1033 mb high had built up over interior valleys although relatively low pressure persisted in the Gulf of Alaska.

The life of this particular cold snap was short, which in itself is unusual. For when a cold air mass settles over interior portions of the territory before days have lengthened appreciably, the cold frequently lasts a week or longer. In this case moist over-running air from the Bering Sea was already causing light snow over western portions of Alaska by 0230 AST of the 25th. It is interesting to note that snow began falling with surface temperatures between $-40°$ and $-50°$. By this time the high center began to split with one portion moving eastward into Canada, the other retreating northwest.

The flow of Arctic air over Alaska now decreased rapidly. Because of this and of the numerous mountain ranges covering the southern half of the territory, the secondary Arctic Front weakened rapidly and its remnants could hardly be traced to the Gulf Coast, leaving only pockets of the extremely cold air in mountain valleys. As the new storm from the Bering Sea pressed northeastward, the front would again appear along the Arctic Slope.

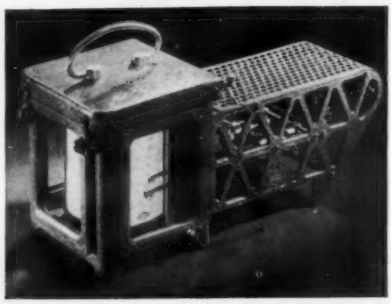
Conclusion

Secondary Arctic Fronts do exist in winter over Alaska and provide definite fixes for the development of "weather" under particular conditions. Therefore, it would appear that the front perhaps should be carried on surface charts, usually on the basis of temperature discontinuity, even when there is no other associated weather.



Upper-air sounding at Fairbanks.

No. 257. Hygrothermograph



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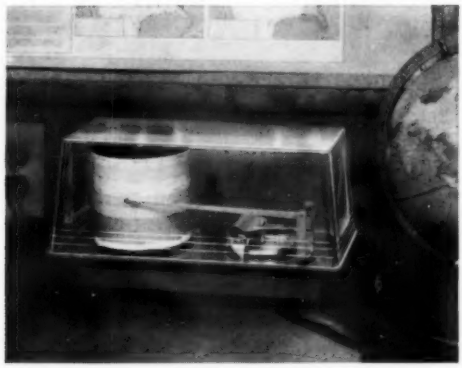

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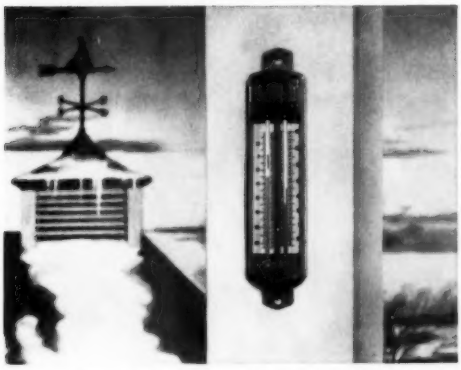

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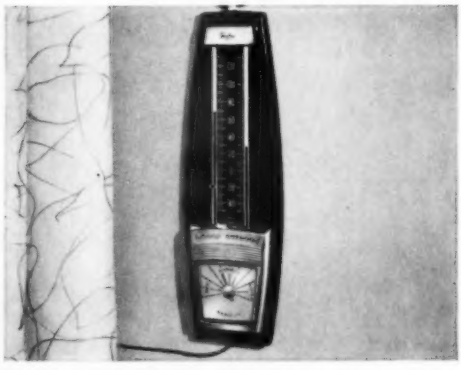

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